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DISCOVERIES OF GANDHARA ART IN BRITISH INDIA.

By our ENGLISH CORRESPONDENT.

SOME highly instructive discoveries of great archæological interest, the results of which afford conclusive evidence of a connecting link between the Greek school and the art of the Far East, have been made by Dr. David Brainerd Spooner, the superintendent of the Archæological Survey of the Northwest Frontier of British India. The site of these excavations was at Sahribahlol, and the fact that this district might possibly yield traces of early Indian art was impressed upon the director in the course of his tour through the country shortly after succeeding Dr. Stein in this office. A cursory inspection of the neighborhood gave abundant evidence of its having been an important center in ancient times; and while he was engaged in preliminary investigations, one of the villagers volunteered the information that if the director were searching for "Buts," he could direct him to a fruitful spot. This was situated about a mile south of the village, where existed a small and inconspicuous mound bearing traces of primitive antiquarian searches. Dr. Spooner made a series of trial diggings, and brought to light within a period of three hours some forty fragments of ancient Buddhist sculpture, both stone and stucco. From this circumstance he concluded that the methodical examination of the mound would undoubtedly yield an extensive and fruitful collection of archæological remains; and in order to arrest the haphazard depredations of the villagers, the consent of the government was sought for the immediate and complete excavation of the site. This was readily granted.

The natives had already sank a pit to the south of the mound, revealing the corner of a wall. Dr. Spooner accordingly set to work making a trench alongside the outermost edge of the mound toward the pit, and in so doing he laid bare the foundation of what proved to be a religious Buddhist building still retaining traces of stucco decoration comprising Buddha figures seated between Corinthian pilasters. Further digging disclosed a wall of Gandhara masonry about 69 feet in length by 4 feet wide and rising to a uniform height of some 3 feet. As the upper surface was perfectly smooth and level, it showed it to be either a stone substructure or basement. This contention was confirmed by traces of the *kaccha* superstructure which it had originally supported being discovered in a crowning layer of earth mixed with *bhusa*. Further investigation supported the theory that it was the main divisional wall of the site, while another wall running at right angles in an easterly direction was brought to light at the northern end of the first wall. The later discovery of a small stupa pointed to the fact that the mound undoubtedly represented an ancient religious establishment, with the monastic quadrangle to the east and the religious precinct to west. As the time available for further excavation was strictly limited, further search was restricted to the last-named section as probably being the situation upon which the best finds would be made.

The stupa had not been uncovered for more than a few inches before the fact was rendered apparent that its original decoration was still preserved, since the stucco ornamentation, comprising a line of friezes consisting of elephants and Atlases alternating, was found not only in position, but remarkably perfect. Dr. Spooner being anxious to secure this discovery intact, postponed the removal of the earth beneath which it was buried for the time being until it had been trenched well all around. Unfortunately, however, upon returning to the site one morning he found that during the night someone, animated by feelings of fanaticism or pure wantonness, had removed the covering earth and with some strong instrument had completely demolished the frieze as far as possible on the three sides which were exposed. Under these circumstances the director resolved upon the removal of the stupa immediately, and promptly excavated the northern side, which

STANDING BOHISATTVA. ONE OF THE FINEST SPECIMENS YET DISCOVERED.

STATUE OF KUBERA AND HARITI. SOME GOLD WAS STILL FOUND ON THE FIGURES.

SMALL STUPA WITH STUCCO ORNAMENTATION EXCAVATED AT SAHRIBAHLOL, BRITISH INDIA.

SEATED BUDDHA FIGURE.

DISCOVERIES OF GANDHARA ART IN BRITISH INDIA.

proved to be the front of the stupa and far more valuable from the decorative point of view, since the frieze was of far greater interest than those which had been damaged. Moreover, by digging the surrounding trench still deeper another lower frieze was brought to light, the decorative scheme as in the case of the religious building consisting of seated Buddha figures between Corinthian pilasters, but the workmanship was of a far higher order. The stupa was photographed *in situ* by the official photographer before its removal, which was then proceeded with.

Continuing the line of the trench in the hope of unearthing additional buildings, a stone platform was brought to light some 4 feet in height by 6 feet square, approached by a flight of steps in excellent preservation. This was evidently the central religious edifice of the community, presumably a stupa, but upon this point no conclusive evidence was available, as there were no traces of such a structure to support this conclusion. Yet a most important and valuable feature from the archæological point was established, namely, a line of stone sculpture comprising with one exception Bodhisattva figures originally about 4 feet 6 inches in height, *in situ* on either side of the approach to this lost building. This line of standing figures was flanked on either side by a seated Buddha figure, only one of which, however, was found actually in position. So far as is known, these constitute the first free standing sculptures that have been found *in situ* in Gandhara, rendering the discovery of exceptional interest and value. Unfortunately, however, the figures were all found to be more or less badly damaged. This condition was largely attributable to the shallow layer of earth enveloping them, and which was quite insufficient to afford any protection to them in their original height. In fact, the jagged points of the neck of one statue were found protruding above the level of the soil before digging was commenced.

In the course of the diggings a considerable number of valuable finds were effected, though it is probable that the most prolific part of the mound had been exploited by the villagers prior to Dr. Spooner's arrival. A large number of Buddha and Bodhisattva figures were brought to light, many of which were in a remarkable state of preservation. A number of heads were found in stone and stucco, as well as several fragments of architectural decorative schemes, such as friezes, cornices, etc. Possibly, however, the cream of the collection consisted of a seated Buddha figure nearly 4 feet in height, the feature of which is the delicacy of its treatment and its preservation; a large standing Bodhisattva figure almost identical with that in the famous collection of the Guides in Mardan; an excellent devotional sculpture representing a Buddha seated between two standing Bodhisattvas; and a large sculpture some 3 feet 10 inches by 4 feet 6 inches executed in stone, representing Kubera and Hariti seated side by side. Dr. Spooner is of opinion that the individuality, the masculine strength of Kubera, and the feminine grace and beauty of Hariti as represented in this last-named piece of work are without equal in the Gandhara school. Its preservation is noticeable, and when unearthed some of the gold used in the original gilding of Kubera's forehead was found thickly clinging to the stone.

Several of the pieces showed traces of coloring (which was originally of an elaborate description) and gilding. The most significant in this respect was a piece of stone halo found with its coating of stucco intact, which in turn preserved its original painted design—a circle of radiating rays in gold on a brilliant red background. When first unearthed, and before the brilliancy of the coloring became dimmed by exposure to the air, this little fragment conveyed a vivid impression of the barbaric splendor possessed by this site in the zenith of its prosperity. Moreover, this small section possesses a distinct individual value, since it is believed to be the first remnant so far recovered of the hitherto assumed school of painting in Gandhara.

Dr. Spooner, however, regards the Bodhisattva figures as on the whole the most interesting discoveries, since the variety and exact determination of the types represented appear to offer conclusive evidence that these figures were differentiated in this school of art to a greater extent and at an earlier date than generally believed. The collection supplies a number of distinct types, and they should furnish valuable material in distinguishing individual figures in this school, which heretofore has not been an easy matter. The director advances the statement that probably the first clue to such differentiation will be contributed by the head-dress.

On the eastern portion of the site nothing of very important note was brought to light. There was the usual arrangement of cells built around the sides of the courtyard. In the center of the court was apparently a tank, the nature of which, however, depends for its determination upon the covered drain that leads from it to the south. Around the walls of this tank are a series of little bays, the purpose of which cannot readily be explained, and no conclusive evidence upon this point will be available until further sites in the vicinity have been examined.

The destruction of the buildings was evidently due to fire, since quantities of charcoal were found in the ruins of the monastic quadrangle, the roofs of which buildings at any rate were carried out in wood. Owing to the unique value of the relics unearthed, which considering the smallness of the site excavated is very extraordinary, the whole of the collection has been carefully removed to the Peshawar Museum, where it occupies no less than twelve cases.

In the opinion of Dr. Spooner, to whose courtesy we are indebted for the information and accompanying illustrations, the exquisite execution of the figures places them definitely in the best period of Gandhara art, that is to say, approximately in the first and second century of the Christian era. This school he moreover maintains (in addition to its historical importance) not only represents the highest artistic achievement of the Indians, but also constitutes a connecting link between the Greek school and the art of the Far East, and is all too little known and appreciated. An exhaustive description of the discovery, in view of its unique significance, is to be published by the government during the present year, while meanwhile Dr. Spooner has arranged to continue his investigations, which it is anticipated will be equally fruitful.

THE MOVEMENTS OF PLANTS.—II.*

IS GROWTH THE RESULT OF MEMORY?

BY FRANCIS DARWIN, M.A., PH.D., LL.D., F.R.S.

Continued from Supplement No. 1708, page 203.

HABIT ILLUSTRATED BY MORPHOLOGY.

We have hitherto been considering the mnemic quality of movements; but, as I have attempted to show, morphological changes are reactions to stimulation of the same kind as these temporary changes. It is indeed from the morphological reactions of living things that the most striking cases of habit are, in my opinion, to be found. The development of the individual from the germ-cell takes place by a series of stages of cell-division and growth, each stage apparently serving as a stimulus to the next, each unit following its predecessor like the movements linked together in an habitual action performed by an animal. My view is that the rhythm of ontogeny is actually and literally a habit. It undoubtedly has the feature which I have described as pre-eminently characteristic of habit, viz., an automatic quality which is seen in the performance of a series of actions in the absence of the complete series of stimuli to which they (the stages of ontogeny) were originally due. This is the chief point on which I wish to insist—I mean that the resemblance between ontogeny and habit is not merely superficial, but deeply seated. It was with this conclusion in view that I dwelt, at the risk of being tedious, on the fact that memory has its place in the morphological as well as in the temporary reactions of living things. It cannot be denied that the ontogenetic rhythm has the two qualities observable in habit—namely, a certain degree of fixity or automaticity, and also a certain variability. A habit is not irrevocably fixed, but may be altered in various ways. Parts of it may be forgotten or new links may be added to it. In ontogeny the fixity is especially observable in the earlier, the variability in the later, stages. Mr. Darwin has pointed out that "on the view that species are only strongly marked and fixed varieties, we might expect often to find them still continuing to vary in those parts of their structure which have varied within a moderately recent period." These remarks are in explanation of the "notorious" fact that specific are more variable than generic characters—a fact for which it is "almost superfluous to adduce evidence." This, again, is what we find in habit; take the case of a man who, from his youth up, has daily repeated a certain form of words. If in middle life an addition is made to the formula, he will find the recently acquired part more liable to vary than the rest. Again, there is the wonderful fact that, as the ovum develops into the perfect organism, it passes through a series of changes which are believed to represent the successive forms through which its ancestors passed in the process of evolution. This is precisely paralleled by our own experience of memory, for it often happens that we cannot reproduce the last learned verse of a poem without repeating the earlier part; each verse is suggested by the previous one and acts as a stimulus for the next. The blurred and imperfect character of the ontogenetic version of the phylogenetic series may at least remind us of the tendency to abbreviate by omission what we have learned by heart. In all bi-sexual organisms the ontogenetic rhythm of the offspring is a combination of the rhythms of its parents. This may or may not be visible in the offspring; thus in the crossing of two varieties the mongrel assumes the character of the prepotent parent. Or the offspring may show a blend of both parental characters. Semon uses as a model the two versions of Goethe's poem:

Ueber allen Gipfeln, ist Ruh, in allen:
Wäldern, hörest du, keinen Hauch.
Wipfeln, spürest du, kaum einen Hauch.

One of these terminations will generally be prepotent, probably the one that was heard first or heard most often. But the cause of such prepotency may be as obscure as the corresponding occurrence in the formation of mongrels. We can only say that in some persons the word "allen" releases the word "Wäldern," while in others it leads up to "Wipfeln." Again, a mixture of the terminations may occur leading to such a mongrel form as: "in allen Wäldern hörest du kaum einen Hauch." The same thing is true of music; a man with an imperfect memory easily interpolates in a melody a bar that belongs elsewhere. In the case of memory the introduction of a link from one rhythm into another can only occur when the two series are closely similar; and this may remind us of the difficulty of making a cross between distantly related forms. Enough has been said to show that there is a resemblance between the two rhythms of development and of memory; and that there is at least a *prima facie* case for believing them to be essentially similar. It will be seen that my view is the same as that of Hering, which is generally described as the identification of memory and inheritance. Hering says that "between the *me* of to-day and the *me* of yesterday lie night and sleep, abysses of unconsciousness; nor is there any bridge but memory with which to span them." And in the same way he claims that the abyss between two generations is bridged by the unconscious memory that resides in the germ cells. It is also the same as that of Semon and to a great extent as that of Rignano. I, however, prefer at the moment to limit myself to asserting the identity of ontogeny and habit, or, more generally, to the assertion in Semon's phraseology, that ontogeny is a mnemic phenomenon. Evolution, in its modern sense, depends on a change in the ontogenetic rhythm. This is obvious, since if this rhythm is absolutely fixed, a species can never give rise to varieties. This being so, we have to ask *in what ways* the ontogenetic rhythm can be altered. An habitual action, for instance, a trick learned by a dog, may be altered by adding new accomplishments; at first the animal will persist in finishing his performance at the old place, but at last the extended trick will be bonded into a rhythm of actions as fixed as was the original simpler performance. May we not believe that this is what has occurred in evolution? We know from experiment that a plant may be altered in form by causes acting on it during the progress of development. Thus a beech tree may be made to develop different forms of leaves by exposing it to sunshine or shade. The ontogeny is different in the two cases, and what is of special interest is, that there exist shade-loving plants in which a structure similar to that of the shaded beech-leaf is apparently typical of the species, but on this point it is necessary to speak with caution. In the same way Goebel points out that in some orchids the assimilating roots take on a flattened form when exposed to sunlight, but in others this morphological change has become automatic, and occurs even in darkness. Such cases suggest at least the possibility of varieties arising as changes in or additions to the later stages of ontogeny. This is, briefly given,

* Presidential address before the British Association for the Advancement of Science at Dublin.

the epigenetic point of view. But there is another way of looking at the matter—namely, that upheld by Galton and Weismann. According to this view ontogeny can only be changed by a fundamental upset of the whole system—namely, by an alteration occurring in its first stage, the germ cell, and this view is now very generally accepted. The same type of change may conceivably occur in memory or habit, that is, the rhythm as a whole may be altered by some cause acting on the nerve-centers connected with the earlier links of the series. The analogy is not exact, but such an imaginary case is at least of a different type from a change in habit consisting in the addition of a new link or the alteration of one of the latest formed links. If we were as ignorant of the growth of human actions as we are of variation, we might have a school of naturalists asserting that all changes in habit originate in the earliest link of the series. But we know that this is not the case. On the other hand, I fully admit that the structure of an ovum may in this way be altered, and give rise to a variation which may be the starting-point of a new species. But how can a new species originate according to an epigenetic theory? How can a change in the latter stages of ontogeny produce a permanent alteration in the germ-cells? Our answer to this question will depend on our views of the structure of the germ-cells. According to the mnemic theory they have the quality which is found in the highest perfection of nerve-cells, but is at the same time a character of all living matter—namely, the power of retaining the residual effects of former stimuli and of giving forth or reproducing under certain conditions an echo of the original stimulus. In Semon's phraseology germ-cells must, like nerve-cells, contain engrams, and these engrams must be (like nerve-engrams) bonded together by association, so that they come into action one after another in a certain order automatically, i. e., in the absence of the original stimuli. This seems to me the strength of the mnemic theory—namely, that it accounts for the preformed character of germ-cells by the building up in them of an organized series of engrams. But if this view has its strength, it has also its weakness. Routine can only be built up by repetition, but each stage in ontogeny occurs only once in a lifetime. Therefore if ontogeny is a routine each generation must be mnemically connected with the next. This can only be possible if the germ-cells are, as it were, in telegraphic communication with the whole body of the organism; so that as ontogeny is changed by the addition of new characters, new engrams are added to the germ-cell. Thus in fact the mnemic theory of development depends on the possibility of what is known as somatic inheritance or the inheritance of acquired characters. This is obvious to all those familiar with the subject, but to others it may not be so clear. Somatic inheritance is popularly interesting in relation to the possible inherited effects of education, or of mutilations, or of the effects of use and disuse. It is forgotten that it may be, as I have tried to show, an integral part of all evolutionary development.

WEISMANN'S THEORY.

Everyone must allow that if Weismann's theory of inheritance is accepted we cannot admit the possibility of somatic inheritance. This may be made clear to those unfamiliar with the subject by an illustration taken from the economy of an ant's nest or beehive. The queen on whom depends the future of the race is cut off from all active experience of life: she is a mere reproducing machine, housed, fed, and protected by the workers. But these, on whom falls the burden of the struggle for life and the experience of the world generally, are sterile, and take no direct share in the reproduction of the species. The queen represents Weismann's germ-plasm, the workers are the body or soma. Now imagine the colony exposed to some injurious change in environment; the salvation of the species will depend on whether or no an improved pattern of worker can be produced. This depends on the occurrence of appropriate variations, so that the queen bee and the drones, on whom this depends, are of central importance. On the other hand any change occurring in the workers, for instance, increased skill due to practice in doing their work or changes in their structure due to external conditions, cannot possibly be inherited, since workers are absolutely cut off from the reproduction of the race. According to Weismann, there is precisely the same bar to the inheritance of somatic change. The racial or phyletic life of all organisms is conceived by him as a series of germ-cells whose activity is limited to varying, and whose survival in any generation depends on the production of a successful soma or body capable of housing, protecting, and feeding the germ-cell. Most people would *à priori* declare that a community where experience and action are separated must fail. But the bee's nest, which must be allowed to be something more than an illustration of Weismann's theory, proves the contrary. It is clear that there must be war to the knife between the theory of Weismann and that of the somatists—to coin a name for those who believe in the inheritance of acquired characters. A few illustrations may be given of the strength of Weismann's position. Some trick or trivial habit appears in two successive generations, and the son is said to inherit it from his father. But this is not necessarily a case of somatic inheritance, since according to Weismann the germ-plasm of both father and son contained the potentiality of the habit in question. If we keep constantly in view Weismann's theory of continuity, the facts which are supposed to prove somatic inheritance cease to be decisive. Weismann has also shown by means of his hypothesis of "simultaneous stimulation" the unconvincingness of a certain type of experiment. Thus Fischer showed that when chrysalids of *Arctia caja* are subjected to low temperature a certain number of them produce dark-colored insects; and further that these moths mated together yield dark-colored offspring. This has been held to prove somatic inheritance, but Weismann points out that it is explicable by the low temperature having an identical effect on the color determinants existing in the wing-rudiments of the pupa, and on the same determinants occurring in the germ-cells. It does not seem to me worth while to go in detail into the evidence by which somatists strive to prove their point, because I do not know of any facts which are really decisive. That is to say, that though they are explicable as due to somatic inheritance, they never seem to me absolutely inexplicable on Weismann's hypothesis. But, as already pointed out, it is not necessary to look for special facts and experiments, since if the mnemic theory of ontogeny is accepted the development of every organism in the world depends on somatic inheritance. I fully acknowledge the strength of Weismann's position; I acknowledge also most fully that it requires a stronger man than myself to meet that trained and well-tried fighter. Nevertheless, I shall venture on a few remarks. It must be remembered that, as Romanes pointed out, Weismann has greatly strengthened his theory of heredity by giving up the absolute stability and perpetual continuity of germ-plasm. Germ-plasm is no longer that mysterious entity, immortal and self-contained, which used to suggest a physical soul. It is no longer the aristocrat it was when its only activity was dependent on its protozoan ancestors, when it reigned absolutely aloof from its contemporary subjects. The germ-plasm theory of to-day is liberalized, though it is not so democratic as its brother sovereign pangenesis, who reigns, or used to reign, by an elaborate system of proportional representation. But in spite of the skill and energy devoted to its improvement by its distinguished author, Weismannism fails, in my opinion, to be a satisfactory theory of evolution. All such theories must account for two things which are parts of a single process, but may logically be considered separately: (i) The fact of ontogeny, namely, that the ovum has the capacity of developing into a certain more or less predetermined form; (ii) the fact of heredity—the circumstance that this form is approximately the same as that of the parent. The doctrine of pangenesis accounts for heredity, since the germ-cells are imagined as made up of gemmules representing all parts of the adult; but it does not account for ontogeny, because there seems to be no sufficient reason why the gemmules should become active in a predetermined order unless, indeed, we allow that they do so by habit, and then the doctrine of pangenesis becomes a variant of the mnemic theory. The strength of Weismann's theory lies in its explanation of heredity. According to the doctrine of continuity, a fragment of the germ-plasm is, as it were, put on one side and saved up to make the germ-cell of the new generation, so that the germ-cells of two successive generations are made of the same material. This again depends on Weismann's belief that when the ovum divides, the two daughter cells are not identical; that in fact the fundamental difference between soma and germ-cells begins at this point. But this is precisely where many naturalists whose observations are worthy of all respect differ from him. Weismann's theory is therefore threatened at the very foundation. Even if we allow Weismann's method of providing for the identity between the germ-cell of two successive generations, there remains, as above indicated, a greater problem—namely, that of ontogeny. We no longer look at the potentiality of a germ-cell as Caliban looked on Setebos, as something essentially incomprehensible ruling the future in an unknown way—"just choosing so." If the modern germ-cell is to have a poetic analogue it must be compared to a Pandora's box of architectonic sprites which are let loose in definite order, each serving as a master builder for a prescribed stage of ontogeny. Weismann's view of the mechanism by which his determinants—the architectonic sprites—come into action in due order is, I presume, satisfactory to many, but I confess that I find it difficult to grasp. The orderly distribution of determinants depends primarily on their arrangement in the ids, where they are held together by "vital affinities." They are guided to the cells on which they are to act by differential divisions, in each of which the determinants are sorted into two unequal lots. They then become active, i. e., break up into biophores, partly under the influence of liberating stimuli and partly by an automatic process. Finally the biophores communicate a "definite vital force" to the appropriate cells. This *may* be a description of what happens; but inasmuch as it fails to connect the process of ontogeny with physiological processes of which we have definite knowledge, it does not to me seem a convincing explanation. For myself I can only say that I am not satisfied with Weismann's theory of heredity or of ontogeny. As regards the first, I incline to deny the distinction between germ and soma, to insist on the plain facts that the soma is continuous with the germ-cell, and that the somatic cells may have the same reproductive qualities as the germ-cells (as is proved by the facts of regeneration); that, in fact, the germ-cell is merely a specialized somatic cell and has the essential qualities of the soma. With regard to ontogeny, I have already pointed out that Weismann does not seem to explain its automatic character.

(To be concluded.)

WHAT IS GRAVITATION?*

By PROF. HAROLD JACOBY.

THE law of gravitation declares that every particle of matter in the universe attracts every other particle of matter. The precise conditions under which such attraction is supposed to have effect I disregard for the moment as a matter of detail. But is there really such a thing as gravitation? Has this law a real physical existence, and does it actually hold sway in our world? In the first place, the law itself is contrary to ordinary ideas of common sense. How can any particle of matter pull any other particle, when there is no connecting link through which the pull can be exerted? This objection we may pass over because we can accept the law even though we are unable to understand just how or why it exists and acts. The question is, to what extent does it enable us to explain for the past and predict for the future all those intricate convolutions of motion that we observe among the planetary bodies in our solar system and even among the distant congeries of stars.

It is a singular fact that all these motions can be thus explained for the past and predicted for the future without using the law of gravitation, yet with an accuracy as great as this law itself renders possible. Existing tables of planetary and lunar motion have been computed by the aid of certain formulas obtained from the law of gravitation by means of mathematical analysis. These formulas consist of a long series of parts or "terms" which must be computed separately and the results added in order to find the planet's position on the sky to be printed in the nautical almanacs and subsequently compared with actual observations for a verification of theoretical law.

Now all these terms are what mathematicians call *periodic* in form. This means that while any given term may increase as time goes on, such increase cannot continue without limit. There must come an epoch when it will again begin to decrease, and so on alternately to the end of time. It was on this peculiarity of periodicity that Laplace based his famous but not quite rigorous mathematical demonstration of stability in our solar system. All terms in all motions being strictly periodic, it follows that all changes in the system are likewise periodic. No matter how intricate may be the changes occurring in the system, these cannot continue indefinitely, and everything must return again to its original form and condition after the lapse of sufficient ages of time.

But the very fact of uniform periodicity in these terms brings out a most curious circumstance. The ancient Ptolemaic theory of the universe was periodic too. Ptolemy made the earth immobile, and all orbits were circular. The revolving planet did not travel in the original circle, but upon the circumference of a second smaller circle, perhaps, whose center moved in the original curve. Now if we apply modern mathematical methods to Ptolemy's theory of the universe, it is possible to show that we can thus reproduce all Laplace's periodic terms by simply postulating a sufficient number of these circles moving one upon the other. For each term in Laplace's series we must have one more Ptolemaic circle. This having been done, the actual formulas to be used in the computation of a planet's place in the sky become identical, whether we deduce them by the methods of Newton and Laplace or from the principle of Ptolemy. Consequently, the agreement between theory and observation is the same either way; and such agreement fails as a test to determine whether Ptolemy or Newton had a correct theory of the universe. The one thing that leads us to accept Newton's law of gravitation is that this law is extremely simple compared with those intricacies of endless eccentric circles. And the human mind chooses to assume that the universe is constructed on a simple plan rather than an extremely complicated one. Thus gravitation rests ultimately to some extent on a mere peculiarity of the human mind.

Now I have no desire to be heralded throughout this land as having abandoned the law of gravitation, and returned to the old Ptolemaic theory of the universe.

* Abstracted from a lecture on Astronomy delivered at Columbia University in the series on Science, Philosophy and Art.

I therefore state explicitly that such is not the case. I have merely called attention to the above interesting facts, in order that I may mention what is the last word of science on this matter. We cannot do better than seek it in Simon Newcomb's 1895 memoir entitled "The elements of the four inner planets and the fundamental constants of astronomy."

Newton, as you know, postulated that the attraction of gravity diminishes proportionately with the square of the distance. If a body pulls another with a certain strength at a certain distance, then this pull will be diminished to one-fourth its former force if the distance between the bodies be doubled. Now there exist certain outstanding discrepancies between observed and computed motions which have never been explained satisfactorily. This does not necessarily prove that the law of gravitation is non-existent, because the failure in explanation may be due simply to the feebleness of man's mathematical powers. Something may have been overlooked somewhere in the endless and seemingly inextricable complexities of mathematical deductions. But this is improbable too; for you may well imagine that no stone has been left unturned by successive generations of able investigators.

For this reason it has been proposed to alter the law of gravitation slightly, so as to explain these little theoretical discrepancies. The proposition is to suppose the attraction to diminish, not as the square of the distance, but in a manner differing very slightly from the square. This I may call the law of modified gravitation. To Newcomb the hypothesis seems "provisionally not inadmissible," and more unobjectionable than others that have been proposed. But in abandoning the Newtonian form of the law we lose its simplicity; which, as I have said, seems to be the strongest argument for its reality.

ARMOR-BEARING ANIMALS.

SOME MARVELS OF PROTECTIVE INGENUITY.

When first mankind discovered the use of protective armor, he probably thought that he had invented something as novel as it was effective. As a matter of fact, his invention was not new at all, but merely a rough-and-ready copy of a protective device employed by Nature from time immemorial. For among animals we find examples of almost every kind of armor, ranging from the tough integument comparable to the shields of hide borne by the savage warrior to veritable suits of mail, reminding us of those worn by knights during the fifteenth century. Indeed, we may even venture the assertion that certain kinds of animals, in the wonderful perfection of their armor plating, bear no inconsiderable resemblance to that marvel of protective ingenuity, the modern battleship, or to a weird, locomotive fort, such as Mr. H. G. Wells has described in one of his stories.

Among mammals we find that armor-bearing species are confined to the strange group Edentata; that is, if we disregard those creatures that are furnished merely with plates of thickened skin, such as the rhinoceros. The true armor-bearing mammals form two small families, namely, the pangolins of Southern Asia and Africa, and the armadillos of South America. The first of these, the pangolins, are among the strangest of all living animals. To describe them in words is by no means easy. Imagine a creature, almost lizard-like in outline, clad from head to tail in a suit of horny plates, like huge, thick finger-nails, overlapping one another as do tiles on the roof of a house. Its head terminates in a long, narrow snout, within which is its sticky, worm-like tongue, used with rapidity and effect when an ant-hill is raided. In walking it uses its fore limbs in a remarkable manner, going "upon the backs of its hands," as it were, and thus preserving its powerful claws uninjured. For not only is it a burrowing animal; it must also break open the hard exteriors of ants' nests, upon the inmates of which it feeds. If the reader has followed this description, he will have gained some idea of the appearance of a typical "scaly ant-eater," or pangolin. It must be added, however, that part of the head and the under portion of the body are unarmed; and this fact accounts for a habit of rolling itself into a rough ball (after the manner of the English hedgehog), which the pangolin exhibits on occasions of sudden alarm. In this posture its scales stand out somewhat; and as they terminate more or less in points, and have sharp edges, they are almost, if not quite, as forbidding as the hedgehog's spines. The origin and character of the pangolin's scales invite another comparison with the hedgehog. For just as the spines of our little native mammal are derived from hair—are, so

TORTISE-SHELL.

to speak, compact masses of hardened hair drawn out to points—so, too, are the pangolin's scales of a definite hair-like character. The late Grant Allen humorously referred to them as "clotted curls"; nor would it be easy to find a better description, for they are actually thick masses of hair-like material—a mere modification, in fact, of hair as we know it in its more common aspect. With the armadillos of South America we approach armor of a quite different kind, despite the fact that the pangolins and the armadillos belong to the same order, and are alike eaters of ants and termites. The plates of armor have nothing to do with hair, nor with any part of the exo-skeleton, but are composed of bone material, deposited in the true skin in the shape of little shields, though each

CARAPACE OF TORTISE UNDER SHELL.

shield is itself covered with a horny plate developed in the outer skin, or epidermis. The actual arrangement of these bony plates varies very much in different species of armadillo. Sometimes, as in the case of the "three-banded" species, there are solid cuirasses above the shoulders and the loins, united by three jointed bands, from which the animal takes its name, and by means of which it is enabled to roll itself into a well-protected ball when danger threatens. For it must be remembered that the armor, broadly speaking, is confined to the dorsal surface; and in the event of hostile attack by a powerful adversary, the armadillo would soon be overcome were it not able, by a muscular contraction, to tuck in its head and limbs, and bring the edges of its protecting cuirasses almost together. Other typical examples of the armadillos are the pichi and the tatouay. In each of these the cuirasses on the shoulders and loins are reduced in size, while the number of jointed bands is increased, giving additional flexibility. The protecting armor is composed of true bone material. The dorsal surface is thoroughly protected—from the tip of the nose to the end of the tail, in fact. When danger threatens, the legs are gathered up close to the ventral surface of the body, the back is bent by a muscular contraction until the edges of the cuirasses are brought almost together, while the armor plates upon the upper surfaces of the head and tail effectually guard the entrance to what has now become a living stronghold.

In passing, it is worth calling to mind the fact that both the pangolins and the armadillos are the last survivors of a very ancient stock. Abundant remains of the armadillo ancestry have been found in the rocks of the South American continent. To-day, the representatives of the family are all small animals, and there can be no doubt that they represent the dwindling remnants of a doomed race. They are, so to speak, creatures of yesterday, and they linger in our twentieth century world merely on sufferance. But of old time the armadillo folk were a dominant race, represented by numerous species and individuals of gigantic proportions. The glyptodon, for example, is known to have been not less than 11 feet in length; while the closely-related chlamydothere was even larger, and would have rivaled in bulk our modern rhinoceros. These great beasts carried upon their backs huge armored domes of bony plates, and must have been absolutely invulnerable. So, at least, one would imagine. Yet the glyptodon and the chlamydothere, besides many other equally well-protected creatures, have long ago perished from the earth, though in what manner their extinction was accomplished it is impossible to surmise. Indeed the total disappearance of these prehistoric giants, many of which seemed capable of setting at defiance every conceivable form of hostile attack, constitutes, perhaps, the most mysterious problem of geological study.

At the present day, the most striking instance of a race of creatures almost universally protected by armor is, perhaps, the tortoises. Tortoises are, of course, reptiles; yet in what may be termed the "make up" of their armor they remind us not a little of the armadillos. For their shells, or carapaces, are formed mainly of bony plates, some of which are an outgrowth from, and actually welded to, the backbone and ribs, while others originate in the true skin, as we saw to be the case with the bony shields of the armadillos. The exterior of the carapace is covered with plates of horny material—the "tortoise-shell"—and these are not, as a rule, welded together. It is noteworthy, too, that the lines formed by the apposition of their edges do not correspond with those which indicate the junctures of the bone foundation plates. This fact reveals to us the origin of the tortoise's armor—namely, that the foundation consists of true bone, an outgrowth, as it were, of the creature's skeleton; while the horny plates had their origin in the epidermis. It also lends support to the idea that tortoises and turtles trace their origin to the same ancient stock as crocodiles and alligators; for in the case of these latter reptiles we find above the more vulnerable parts of the body great horny shields in the skin, and beneath these well-developed plates of bone. It remained for the tortoises, however, to work out this idea to its logical conclusion, enlarging the scattered plates of armor until they covered the whole body and formed one strong box, into which the owner can withdraw its head and limbs, and lie in safe retreat from its would-be assailants.

To discuss in detail all the many forms of armor which have been developed in different groups of the animal kingdom would be to exceed the limits of a short article, for armor plating of one kind or another is Nature's most common protective device. In conclusion, therefore, we must glance at one or two invertebrate armor-bearing animals, selected almost at random from thousands of possible examples. Among insects armored protection is very common, many

RIDGED ARMOR OF CLAM SHELL.

kinds of beetles exhibiting it in the greatest perfection. Here, too, we find that armor becomes at times a type for "mimicry." That is to say, the *appearance* of hardness is possessed by beetles that are in reality not hard at all. Armored beetles are probably perfectly edible, but it is impossible for the majority of insectivorous birds to feed upon them, because their beaks are not strong enough to pierce the almost stone-like wing cases and thorax. The external appearance

of many such beetles is accurately copied by others, the actual thickness of whose casing forms a quite inadequate protection. Such species, when compared in a cabinet, are scarcely distinguishable by the ordinary observer; yet the one specimen might be crushed between the finger and thumb, while the other would need a smart blow from a hammer to destroy it.

Lobsters and crabs are also capital types of armor-bearing animals. The former possess wonderful coats

FOSSIL OF GLYPTODON FROM BUENOS AYRES.

of mail, strangely suggestive of those devised and worn by human warriors in the age of chivalry. They combine perfect security with ease of movement, owing to their jointed structure. Crabs, on the other hand, have pinned their faith to the strong-box type of protection, such as we saw to be fashionable among the tortoises. The manner in which crabs, when at rest, tuck their legs beneath them, so as to bring them under the shelter of the hard carapace, is very interesting; so, too, is their striking resemblance, when in this attitude, to a water-worn pebble, for the crab is one of those creatures upon whom Nature has conferred twin protective characteristics—it looks like the inedible objects by which it is generally surrounded, and is also fully armored. We find a plausible explanation of this in the fact that certain large fishes, such as the cod, are in the habit of swallowing crabs, shell and all. Against such foes as these it is plain that the crustacean's armor is of no avail, whereas its protective resemblance probably stands it in good stead.

Star fishes, especially those of tropical seas—giants measuring from 15 inches to 20 inches across—show us a type of armor not unlike the tough, embossed shields characteristic of early warfare. Their integument is hardened by the presence of much calcareous matter, and studded with bosses of the same hard material. Among sea-urchins we find the strong box again predominating. True, many of these strange-looking creatures are amply supplied with sharp spines, which have earned for them the title of "sea-hedgehogs." But although these spines serve often the purpose of protection, their efficacy varies much in different forms; and as the greater number of the regular urchins progress chiefly by the aid of their spines, it is probable that their original use was am-

THE PANGOLIN'S PLATING.

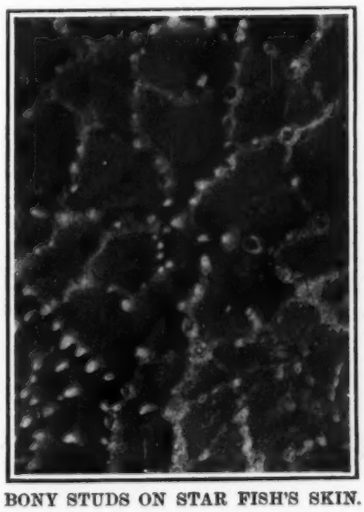
bulatory. The protective value of the wonderfully-constructed test, or shell, on the other hand, is beyond question.

As a final instance of armor-bearing animals, the great group Mollusca may be advanced. The ridged strength of such shells as those of the giant clams speaks for itself, and when we remember that the two valves are held together by muscles of almost invincible power, we realize in what a stronghold the owner of the shell resides. Fiction relates that incautious bathers in tropical seas have put their feet into the gaping valves of such shells, and have been held captive until drowned by the rising tide. Whether any such cases have a foundation in fact the writer is unable to say, but that the giant clam possesses the power necessary for the accomplishment of the grim feat is beyond question. Examples of *Tridacna gigas*, the largest known bivalve, have been found to measure more than a yard in length, and to turn the scale at 500 pounds.—Country Life (London).

OCCUPATIONAL MORTALITY.

THERE has just been published a supplement to the sixty-fifth annual report of the Registrar-General of Births, Deaths, and Marriages in England and Wales. This supplementary report deals with occupational mortality, and corresponds generally to Part II. of the supplementary report which ten years ago Dr. Tatham submitted. The earliest attempt to ascertain by appeal to actual experience the various degrees of danger to life incurred by men engaged in different occupations was made by Dr. Farr, C. B., F. R. S., in the year 1864, and in the three decennial supplements issued since that date the attempt has been renewed by him or his successors. The object of the present work is to furnish trustworthy material for continuing the study of the mortality prevailing among the workers in the various occupations, a study the national importance of which is now only coming to be adequately recognized notwithstanding that its value was fully demonstrated by Dr. Farr nearly half a century ago. Whether or not the results of the study of occupational mortality shall be satisfactory must, of course, depend on the precision with which particulars are recorded at the census, and in the death register, respecting the different grades of workers, but, unfortunately, the information on this point in successive census reports is not uniform.

To come to details, the comparative mortality of barristers and solicitors is lower than in any other of the professional classes except the clergy and schoolmasters. As compared with occupied and retired barristers and solicitors, law clerks experience a mortality which is higher at every stage of life. Tuberculosis, phthisis, and disease of the respiratory organs are the only causes of death that are substantially less fatal to medical men than to occupied and retired males in the aggregate. The mortality of school teachers is below the standard for all occupied and retired males at all stages of life, and is but little more than half that standard at the ages of 25 to 45 years. Musicians and music masters fare badly. The mortality incidental to this group is exceedingly high, and at each division of the working period of life the members of it die much faster than do occupied and retired males generally, but at ages below 20 and above 65 they die less fast. It is impossible, says Dr. Tatham, "to escape the conviction arrived at ten years ago, that many of the men included in this group are sadly addicted to intemperance." The life of the domestic indoor servant is exceptionally healthy, more especially that of domestic male servants, who at every age experience lower mortality than do occupied and retired males generally. Commercial travelers fall victims to alcoholism in greater proportion than do all occupied and retired males by 39 per cent, while their mortality from liver disease is more than double that standard. They are said to be "inordinately prone to suicide." The mortality of commercial clerks is high, and that of railway engine-drivers and stokers from accident is excessive, being 15 per cent above the average, but from every other cause of death, except diabetes mellitus, they suffer considerably less than the average mortality. During the middle period of life the mortality of railway guards, porters, and pointsmen is below the average. The comparative mortality figure in the main working period is 19 per cent less than the standard; from accident their mortality is nearly double. Domestic coachmen and grooms die less rapidly than do either cabmen or carriers, their mortality approximating to that of domestic servants at all ages except the most advanced. Seamen fall victims to alcoholism and diseases of the liver much faster than do other occupied and retired males. Their loss of life from accident exceeds even that of bargemen, being nearly four and a half times that of occupied and retired males generally. Both bargemen and seamen suffer loss of life at every group of ages greatly in excess of that of other occupied and retired males, the principal factor being accident. The mortality of dock laborers throughout the main working period is considerably above the average. Among the various sections of the agricultural class the death-rates are not only below the standard for all occupied and retired males, they are also generally below the rates among all males in the selected health districts. As compared with all occupied and retired males, the death-rates of fishermen are above the standard up to the forty-fifth year of life, all between 45 and 65 are considerably below it. Publicans between the ages of 25 and 65 years show a higher mortality than any other section of the trade. Their liability to death from accident is relatively small, but the mortality from suicide is more than twice the average. Taking 11 occupations representing the class of shopkeepers at every age, the mortality is below that of occupied and retired males generally. On the other hand the mortality from alcoholism and from disease of the liver shows a considerable excess. Among hairdressers the mortality from alcoholism and diseases of the liver is high, being more than double the standard, while that from suicide shows an excess of one-fourth above. Tanning seems to be a healthy trade. At the earlier and later ages the mortality of tanners differs little from the standard, but between the ages of 20 and 45 it falls considerably below the average. The mortality of plumbers, painters, and glaziers is very high, the excess is most marked under the heads of plumbism and Bright's disease, but there is also a substantial excess in the mortality from phthisis and diseases of the nervous system. The mortality of sawyers is the lowest in any section of the building trades. The mortality of textile dyers, bleachers, and printers in the main working period is 11 per cent above the standard, and the mortality of glass workers exceeds the standard for occupied and retired males at all the ages of life by proportions ranging from 12 to 32 per cent. In the mining industry, as a whole, the death-rate of men under the age of 20 years exceeds by 30 per cent the standard for occupied and retired males. At ages of 20 to 25 the mortality is normal, but from the age 25 to the age 55 it is below the standard, being in defect by no less than 25 per cent at the ages of 35 to 45. In the main working period of life the comparative mortality figure is 11 per cent below the standard, notwithstanding the excessive mortality from accident, which is more than twice the normal. Among the lead miners, the comparative mortality exceeds the standard by 20 per cent, but the mortality of workers in stone and slate quarries only very slightly exceeds the average. The mortality of general laborers is enormous throughout the whole of life. In the main working period the comparative mortality is nearly 2½ times the standard for occupied and retired males from each separate cause of death, also the mortality among laborers is excessive, that from alcoholism and liver diseases being nearly six times and that from phthisis, from diseases of the nervous, circulatory, and respiratory systems, and from accidents being double the standard, while from the other principal diseases it is nearly double the standard. Although the mortality among engine-drivers, stokers and firemen is low, nevertheless it exceeds that among the corresponding workers among the railwaymen at all ages of life except from 15 to



BONY STUDS ON STAR FISH'S SKIN.

20 years. Among chimney-sweeps the comparative mortality is above the standard by about one-third part. By far the greatest excess of mortality in this occupation is attributable to cancer, for which the comparative figure is 2½ per cent above the standard. Chimney-sweeps appear to be exceptionally addicted to alcoholism, and their mortality from phthisis, diseases of the nervous, digestive, and respiratory systems, and from suicide, is also high. On the other hand they appear to be but slightly liable to influenza, Bright's disease, and to accident. The comparative mortality of Civil Service messengers is 21 per cent below the standard, and that of gamekeepers is remarkably low, being in the main working period of life 42 per cent less than the standard.

Taking the general body of occupied males between the ages of 25 and 65 we find the mortality lowest among clergymen, priests and ministers, then come gardeners, nurserymen, seedsmen, gamekeepers, farmers, graziers, railway engine-drivers, stokers, firemen, laborers, the highest mortality being among innkeepers, publicans, costermongers, tin miners, and general laborers.—Journal of the Royal Society of Arts.

THE PREPARATION OF TOBACCO.*

ITS CULTIVATION AND ITS CHEMISTRY.

BY DR. W. DONSELT.

Tobacco, an annual plant, of the order of *Solanaceæ*, is indigenous to tropical America, and is cultivated in America, Europe, and Asia. As soon as it is ripe, it is slowly dried with the greatest care in specially constructed buildings, so-called drying barns, until it becomes "barn-ripe." As a general rule, in Germany, the leaves are strung separately on cords and hung up; in America the entire plant is cut off just above the root and suspended upside down in the drying place. The leaves remain alive under this treatment, when hung in the drying barns, and processes occur in them that are essential to the production of a perfectly barn-ripe article. Thus, for instance, the plant consumes the starch by respiration, the albuminous substances are decomposed, and the quantity of amides increased; the color of the tobacco, at first green, gradually changes to brown.

Before the drying proper, the tobacco is often allowed to sweat, and to accomplish this the leaves are piled in heaps on one another. Soon after this, heating takes place in the interior of the heaps, due to the fact that the still living leaves begin to breathe. By this mode of treatment it is claimed that the tobacco leaf attains a better ripeness and dries better. Above all things, however, the temperature of the heap must be carefully watched, for if the leaves get too hot they stew and turn black.

In the drying proper, micro-organisms play no part. But if the drying is not carefully enough conducted, e. g., if the particularly thick ribbed leaves, which are slowest in drying, are not placed far enough apart, so that the air and natural heat will have free access to them, the leaves very rapidly spoil. As Müller-Thurgan found, it is a fungus of the species *Pleospora* that attacks the leaves and causes the so-called "barn blight." We may in such case note the gradual appearance on the leaves of dark colored to black spots, growing gradually larger, which, with sufficient moisture, may even cover the entire leaf. The leaf is soft and moist, and tears at the slightest touch. Sturgis found, in cases of rotting of this character, two different types of bacteria, a rod bacterium and a micrococcus, living together on the leaves.

These diseases attack only the tobacco leaves; the stems of the entire plants hung up to dry are attacked by the so-called stem-rot. On the stems white, velvet-like spots appear, which gradually extend farther along the leafribs. Behrens, who investigated these spots, found that they consisted of the mycelium of *Botrytis longibrachiata Oudem*. This fungus gradually destroys the entire tissue of the leaf.

In addition, the quality of the tobacco is disadvantageously affected by the artificial fertilization of the fields with Chili saltpeter. This promotes, for instance, the occurrence of stem rot and "barn blight." The tobacco leaf is certainly made thicker and fleshier by resort to saltpeter fertilization, and in consequence contains more water. This prolongs the drying process in the sheds and affords the fungi of putrefaction an opportunity to establish themselves. In addition, the substance of the tobacco by this method of fertilization becomes a peculiarly favorable field for *Botrytis*.

The tobacco being now barn-ripe, passes into the hands of the manufacturer or dealer, who then subjects it to fermentation. The tobacco bunches are piled together in great heaps, each containing many hundredweight, upon which the entire mass begins gradually to become heated. This spontaneous heating, due to fermentation, will advance in the interior of the heap to a temperature of 142 deg. F., as Suchsland found, but such a high degree of heat should be avoided; it should not be allowed to exceed 122 deg. F. Should it occur, the heaps must be taken apart, the outside leaves placed in the center and those in the center on the outside of the heap. Work is continued in this manner until the entire mass appears to be sufficiently fermented.

During the fermentation of the tobacco leaves, which proceeds under the generation of considerable spontaneous heat, a fairly considerable loss of substance occurs. Thus, in fermented raw tobacco, there is a lack of carbohydrates soluble in water, like sugar and the organic acids, for instance the malic and citric acids still found in barn-ripe leaves, whereas the amount of starch remains unchanged during the fermentation. In addition, the albuminous substances are decomposed, amides being developed; a decrease in the amount of nicotine is also said to be caused thereby. This, however, can occur only as a result of the activity of fermentation organisms, for in tobacco nicotine is not found in a free state, neither in the unfermented nor fermented leaf, but occurs in the form of non-volatile compounds. The nicotine can therefore not be volatilized by heat during fermentation, as confirmed by nitrogen determinations before and after fermentation. The amount of nitrogen, if we take into consideration the loss of dry substances during fermentation, was the same. The micro-organisms that are active in the fermentation use probably a portion of the nicotine as nutriment and transform it into other combinations. Behrens found, for instance, that the mold fungus *Botrytis cinerea* can supply its requirements of nitrogen from the nicotine, just as bacteria placed in a nicotine nutritive solution gradually effect its complete elimination.

As regards the volatile acids in tobacco, it was found that after fermentation they had doubled in quantity. Lactic acid could not be discovered in fermented tobacco; on the other hand, butyric acid was probably formed.

In regard to the organism germs found in the fermentation the bacteriological investigations of Vernhout are worthy of special notice. He used for his observations East Java tobacco. During its fermentation he first of all directed his attention to the thermophile bacteria and he consequently kept the cultures constantly at 122 deg. F. At this they contained invariably the same kind of bacillus. This was actively mobile and formed endospores belonging to the group of the potato bacillus, and it grew likewise at ordinary temperature. In addition, it did not grow as well in a nutritive medium containing tobacco decoction as in one free from tobacco, and in bouillon developed ammonia. Only later Vernhout discovered that the tobacco used by him in the preparation of the tobacco decoction he employed had been subjected to a fermentation, and the experiments which he subsequently instituted with a decoction of barn-ripe tobacco showed that the above-mentioned thermophile bacillus, *Bacillus tabaci fermentationis*, grew well in it. The temperature optimum for growing and flourishing was between 111 deg. and 122 deg. F. The temperature limits were between 77 deg. and 136 deg. F.

Vernhout essayed in the following manner to inoculate a pure culture of the *Bacillus tabaci fermentationis* on tobacco leaves: He halved the tobacco leaves, which were but slightly fermented, on the line of the central rib and then, after further reduction, distributed the halves in Petri dishes in such a manner that the right half of the leaves came into one, the left half into the other part of the double dish. After the halves had been sterilized at 248 deg F., they were inoculated with pure culture of the *Bacillus tabaci fermentationis* and all the dishes left in a thermostat at 122 deg. F. Of seven experiments only three furnished favorable results and, as a fact, in one of these experiments the tobacco leaf halves, after about twelve days, developed a marked odor of sweet rye-bread, a flavor that is almost invariably noticed in tobacco fermentation. Unfortunately Vernhout left Java too soon, so that the investigations could not be continued.

Another investigator, Koning, observed the fermentation of Dutch tobacco. He found invariably numerously distributed in fermenting tobacco *Bacillus subtilis*, as well as mycoides, also the *Bacillus tabaci*, in three different types. Of these two belonged to the Proteus group, the other, the only spore-forming variety, to the Subtilis group, which played the chief part in the fermentation. Koning also, like Vernhout, inoculated sterilized tobacco with pure cultures of these different organisms and then allowed them to ferment for six weeks. After this period, he determined that the tobacco inoculated with the *Bacillus tabaci*, belonging to the Subtilis group, was the best, which was also confirmed by practical experts.

In addition, Koning also isolated a *Diplococcus tabaci*, which took part in the fermentation and the optimum of growth of which was 75 deg. F. At a higher temperature of the made-up tobacco heaps the activity of the diplococcus ceased and in the same manner the bacteria of the Proteus group died off during the fermentation; the bacillus of the Subtilis group, on the other hand, continued to grow. Of the bacilli mentioned, the *Diplococcus tabaci* is said to improve the combustibility; the *Bacillus tabaci*, of the Proteus group, the aroma. Koning, who tested these bacilli in the course of various experiments, determined that an improvement in aroma and taste was invariably recognizable, in some cases he observed even an improvement in the combustibility and in each case the inoculated tobacco was better than that which had not been inoculated. As regards the inoculation of the leaves with bacteria, Koning did not use for this purpose bacteria suspended in water, but a mixture of the bacteria with tobacco powder, which was then blown into the tobacco bunches.

In 1899, Loew determined that the fermentation of tobacco leaves was not effected by living organisms, but by oxidizing enzymes of the tobacco leaf itself. Where bacteria or other organisms obtained access during this process, they caused damage. According to his observations, the number of bacteria decreased with the advancing fermentation, in place of increasing, as other investigators had found. Loew found among the oxidizing enzymes in the tobacco leaves an oxydase which at once colored tincture of guaiac blue, also a peroxydase which only colored tincture of guaiac blue in the presence of peroxide of hydrogen.

The tobacco oxydase died when a watery solution was heated to 149 deg. to 151 deg. F., the peroxydase at 188 deg. to 190 deg. F. Both were present in fresh, barn-ripe, and fermented tobacco, but after a few years were destroyed. In a Florida tobacco, kept for two years, Loew found only the peroxydase. According to his opinion these oxidizing enzymes act during the barn-ripening and fermentation on the tannin and the nicotine like the diastase on starch. Consequently, chemical changes occur in the tobacco leaf. According to an experiment the nicotine is attacked by the tobacco oxydase, ammonia being formed. It is possible that during the fermentation new quantities of oxydase are formed from a zymogen. To what extent the peroxydases, catalases, participate in this remains to be determined by precise investigation.

As regards the disturbance in the fermentation process, too large a proportion of moisture, as far as we have to deal with organisms, may prove dangerous. There may easily occur then, owing to the action of decomposing agencies, decomposition phenomena. Thus, in the fermenting rooms, the thread fungus *Botrytis* was found, in a damp bale also the bacteria of butyric acid.

After fermentation, the tobacco is subjected to different processes. The different sorts are mixed together, the tobacco is kilned, extracted and allowed to age. As far as the aging of tobacco is concerned, saccharine substances are frequently added, yeast and invariably water. These are the so-called "sauces." Directions for this are given by Wagner, Kissling, and others. Another method of aging consists in so-called petunizing. For this purpose leaves that are of little value for cigar making and are still faultless as to aroma are selected and allowed to remain about eight days in water, where they begin to rot. After the tobacco crop has completed its fermentation and the leaves are dry, they are made up into separate bunches and sprinkled with a little water, but so that the leaves are not too wet. Too great a softening of the leaves must be avoided, otherwise decomposition occurs too readily. The leaves are then done up in bundles and the superfluous water allowed to drip off. After the

* Pure Products.

bunches have hung for a few hours in the drying house they are packed, pressed firmly together, into boxes. Here a fermentation takes place incited by the fermentation organisms introduced into the leaves with the water of maceration.

The effect of the petunizing fluid is due to the carbonate of ammonia developed during the fermentation of tobacco leaves or stems and which increases the alkalinity of the tobacco treated. According to Loew, it increases the activity of the oxidizing enzymes. For this reason carbonate of ammonia is frequently used directly in petunizing fluid, to which other additions, such as rum, molasses, wine, etc., are made.

Splendore found that the simultaneous treatment of tobacco with petune and carbonate of ammonia improved both its flavor and aroma. In addition, the same investigator discovered that the tobacco was improved by pasteurizing in live steam at a temperature of 140 deg. to 212 deg. F. Here the characteristic odor of a well-conducted fermentation, the bread aroma, occurs. Pasteurization increases the durability of the tobacco; mold fungi, yeast, and bacteria which exist on the green leaves are killed, according to Splendore. In addition the flavor is improved and the color made uniform and darker.

As far as the aging or maturing of the tobacco is concerned, this is sometimes of no advantage as far as quality is concerned. Very often it is the cause of the development of organisms that cause cigars to become moldy and greatly detracts from their quality. Behrens discovered that the moldiness of cigars was caused extensively by the common *Aspergillus glaucus*.

After all that has been advanced it is very probable that bacteria, in the fermentation of tobacco, play a part very similar to that noted in the spontaneous heating of hay. Unfortunately we have not as yet succeeded in finding fine bacteria that will bring good fortune to the business, nor a domestic tobacco that could be improved by pure culture.

VON ZEPPELIN'S FORGOTTEN PREDECESSOR.

ZAMBECCARI'S WONDERFUL AIRSHIP IN 1803.

THE name of the man who apparently first succeeded in steering an airship has long been forgotten by the generality of mankind and is preserved only in the French "Biographie Universelle," in a little-known book of travels by Kotzebue, and perhaps in a few technical works. It is worthy of remark that this pioneer in aviation was neither a physicist nor a mechanician, but a naval officer.

Count Francisco Zambeccari was born in Bologna in 1756. After completing his education, which was a very good one, he entered the Russian navy. In 1787 he was captured by the Turks and held prisoner in Constantinople for three years, but finally obtained his liberty through the intercession of the Spanish ambassador. Thenceforth he devoted his entire attention to the problem of directing the course of a balloon. His predecessors, with the exception of Leonardo da Vinci, had constructed fantastic devices which had no basis in experiment or observation of nature. Zambeccari, on the contrary, investigated the peculiarities of atmospheric currents and was the first to conceive the idea of controlling the course of a balloon by rising or sinking from an unfavorable to a favorable current in which oars could be used to advantage. In order to carry out this idea it was necessary to construct a balloon which could be raised and lowered at will, and this Zambeccari succeeded in accomplishing. The inventor was killed in 1812, by the wreck and explosion of his airship, in which he had ascended during a storm.

Kotzebue had found him in bed, suffering from the effects of an earlier accident. Kotzebue says: "I learned the details of his ever-memorable flight through the air and saw the lamp which enabled him to rise and fall at will. It is undeniable that a balloon in equilibrium with the surrounding air can be moved horizontally by an exceedingly small force. This force in Zambeccari's balloon is furnished by small attached vanes. I was assured by several eye witnesses that he undertook to fly to and return from two towers, situated in different directions from the starting point, and accomplished both tasks with a very small expenditure of force."

One of Zambeccari's memorable flights was made in 1803. He was enabled to construct his airship by the interest of the celebrated mathematicians, Saladini and Canterzani, who induced the government of Bologna to grant him a subsidy of about $1200. The flight had been announced to take place on September 4, but bad weather and small defects in the balloon had necessitated a postponement until October 5. On that day the weather was again unfavorable, but Zambeccari was driven by the jeers of the spectators, as he said afterward, to attempt the flight. The balloon was carried out to sea, where it and its half-drowned occupants were secured by fishermen and taken to Pola.

Although this attempt had ended in so disastrous a failure, the professors, Saladini, Canterzani, and Avanzini, to whom the matter had been referred by the government, brought in a favorable report, which was printed November 9, 1804. This report is not accessible to the present writer, but Kotzebue, who appears to be well informed, gives substantially the following account of it.

The referees lay down the following law: "If a partly-filled balloon is in equilibrium with the air at any point, for example, near the ground, it will remain in equilibrium when it is transported to any other point of the atmosphere, so long as the gas is allowed to expand or contract." In other words, the volume of the partly-filled balloon varies inversely as the density of the surrounding air. The referees acknowledge that this law was discovered and demonstrated by Zambeccari. Then they speak of his lamp, of the absence of danger in the use of fire and inflammable gas in the same apparatus, and of the manner in which Zambeccari, with the aid of the lamp, was able to ascend, descend or remain stationary at will, without using a single valve, losing any inflammable gas or throwing out any ballast. Then they describe the rudders, by means of which the inventor had previously propelled a light car suspended from the roof of a church, in the presence of many persons. They assert that Zambeccari, in his last flight, hovered a long time over Bologna, ascended and descended at will, and described an arc round the city from south to west, solely by means of his flame and without throwing out ballast, for they had observed him carefully with telescopes. In conclusion they state that Zambeccari has succeeded in proving his theory by actual flight and that the misfortune that has twice overtaken him can detract nothing from his fame or the value of his invention.

The balloon used by Zambeccari was of the type known as a *rozière*, consisting of a *montgolfière*, or fire balloon, in combination with a gas bag, the latter giving a constant buoyancy, while ascent and descent could be accomplished by regulating the flame of the hot air balloon, without expending gas or ballast. Just what the "oars" were with which he drove his craft is not clear.—Umschau.

EXPLOSION AND FLAMELESS COMBUSTION.

THE conditions under which explosive mixtures of gases can be ignited by electric sparks and by glowing bodies are now attracting attention in all countries. It is a matter of great importance in view of the rapid introduction of electric machinery in coal-mines, and already there is a considerable amount of experimental data available for those interested. The latest experiments are those of MM. H. Couriot and Jean Meunier, who have made an extensive series of experiments of the action (1) of incandescent wires or filaments, and (2) of electric sparks, on mixtures of methane with various proportions of air, the gas being sometimes at rest and sometimes in motion. A current of a mixture of 80 per cent of methane with 20 per cent of air could not, they found, be ignited by an incandescent wire or by the spark produced when the wire melted owing to the intensity of the current, though in contact with a flame the mixture readily ignited. Whatever the proportion of methane and air, the only effect produced by an electric spark, if any effect were produced, was an explosion, not quiet combustion. Under no circumstances were they able, in these experiments, to cause an explosion by means of an incandescent wire. When an explosion was caused, it was found to be due to the breaking of the wire, and the consequent production of a spark. The most readily explosive mixture contains 9.5 per cent of methane, and slight explosions were observed with so low a proportion as 4.5 per cent. The maximum limit of explosibility is 12 per cent of methane, and this was shown by the fact that they never obtained an explosion when the percentage reached 12.25. So long as the proportion does not fall below 5.5 per cent combustion during the explosion is complete. If the current by which the wire is heated is shunted with a parallel shunt, the production of the spark causes no ignition when the resistance in the two branches is equal. If the resistance of the shunt is high, the production of a spark always leads to the ignition of the mixture; on the other hand, when the resistance of the shunt falls below a certain value, the production of a spark again causes an explosion. In order to avoid an explosion, the intensity of the current must not exceed a certain maximum, which depends on the resistance of the two branches of the conductor. (Comptes Rendus, 145, pages 1161 to 1163.)

In explanation of the observations that an inflammable mixture of methane (marsh gas) and air is not ignited by an incandescent wire or filament unless the wire fuses and a spark is produced, it is suggested that the incandescent filament attracts the molecules of oxygen and repels those of the hydrocarbon in the mixture; the zone of gas, therefore, surrounding the filament is too poor in the hydrocarbon to be inflammable, and slow or rapid combustion occurs with the formation of water and carbon dioxide. When, however, the filament employed is sufficiently large in volume to raise by its radiation the temperature of the surrounding inflammable mixture beyond the inert zone to about 650 deg. Cent., it appears that an explosion may occur. Hauser has recently shown that, while an incandescent ferro-nickel wire 0.3 millimeter in diameter does not ignite a mixture of 9 per cent of methane with air, a soft-iron wire 0.9 millimeter in diameter caused an explosion in six out of seventeen times.

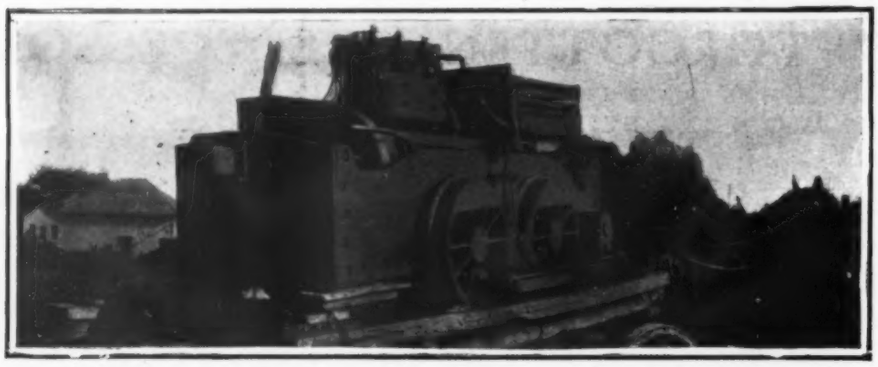
M. Jean Meunier has continued these researches: (1) determining the limits of inflammability of explosive mixtures of ether and air, also Boudouard and Le Chatelier; and (2) investigating combustion without flame and the inflammation of gases at the end of a metallic rod. (Comptes Rendus, 146, pages 539 and 540.) In the last-named an interesting experiment with an alcohol-fed incandescent burner is described. The burner is supported on four tubes, through which cotton wicks pass, supplying the alcohol. It is of annular form, the flame rising from a central cylinder which is covered with a convex disk, perforated with closely-spaced holes. An iron stem 8 centimeters long, supporting the mantle, rises from the center of the disk. It is observed that after continued use the light becomes less bright, and that the darkening of the mantle commences at the moment that the disk reddens. After removal of the mantle the author succeeded in getting the disk to redden without production of a flame. Once the disk is red hot, its incandescence increases with the supply of alcohol vapor. It is impossible to ignite either a pad moistened with alcohol, a wick soaked in light petroleum, or a wooden match, by bringing them near the hot disk, although the wood of the match is charred. This flameless combustion occurring on the surface of the disk is to be explained by the retention of either the combustible gas or the oxygen on this surface, as suggested by Couriot and Meunier in the case of the non-explosion of an explosive mixture by an incandescent filament. Application of a lighted match to the upper end of the metallic stem results in the production of a flame at this point, which continues to burn so long as it is protected from drafts, showing that the oxygen is retained by the disk, and that the excess of combustible gas rises around the stem without mixing with the surrounding air and without igniting, although the stem is at a fairly high temperature. The shape of the flame can be altered by varying the form of the upper extremity of the metallic rod. The experiment, besides its important bearing on the mechanism of combustion by incandescence, seems to indicate that gases have a certain amount of cohesion. It may be noted in passing that the late Mr. Thomas Fletcher, of Warrington, on more than one occasion, several years ago, publicly performed experiments showing the flameless combustion of coal-gas.—Engineering (London).

According to a recent consular report the large deposits of peat in the world, which have hitherto been of practically no value, may prove to be of great worth if the recent experiments of a French chemist, Raynaud, in distilling alcohol from peat prove to be practical, as now seems probable. The cellulose of the peat is hydrated and converted by means of sulphuric acid into a soluble carbohydrate, which is fermented by means of a special yeast, which has hitherto been kept secret. According to statements made by Prof. Ramsay, one ton of dry peat is said to furnish about 43 gallons pure spirits and about 66 pounds of sulphate of ammonia of 100 per cent. It is asserted that the manufacturing costs of 1 gallon of alcohol of 97 per cent are at most 10 cents, whereas the cost of the process of distilling from potatoes is about 35 to 40 cents.

A GAS LOCOMOTIVE.

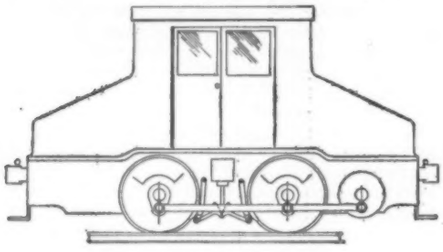
A NOVEL HAULING ENGINE.

A new gas locomotive, embodying some novel features in its construction, is shown in the accompanying cuts. The driving has been carefully worked out to avoid some of the disadvantages of chain or gear transmissions as adapted to this class of engine. The



THE LOCOMOTIVE IS SMALL AND COMPACT, COMBINING SIMPLICITY OF CONSTRUCTION WITH STRENGTH.

body or frame is of heavy iron or steel casting with the engine rigidly mounted thereon, and connected to a countershaft at right angles by bevel gears. A strong friction clutch is arranged between these gears and the engine. This countershaft is journaled rigidly into the frame, and a second one similarly journaled is placed exactly below it; the two being connected by speed gears. The rigid frame and the mechanism in it rest on springs over the main journals, so that the only weight resting rigidly on the rails is that of the wheels and axles, all the rest being borne on springs, thus avoiding vibration. The crank, or lower countershaft, has cranks fitted similar to the usual locomotive type, with side rods, and drive wheels are connected in the usual way. The side rods are bushed at the pin bearing, allowing easy renewal. This



AN ENGINE FOR MINING WORK.

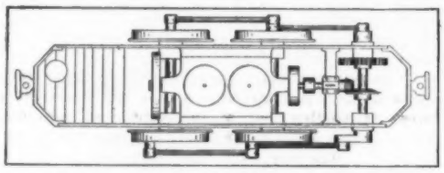
method of transmission seems strong and simple. By having all the wheels driven the load is evenly distributed and the frictional contact with the rail equalized, thus adapting the engine for hard use, and preventing local wear.

A low-down type of engine is constructed for mining or quarry use or for any light haulage on narrow gage tracks. This type is built in sizes up to six tons designed to haul 180 tons on the level. Other types are for switching, and the completely inclosed style is for interurban passenger service, with a baggage compartment; and can attain a speed of 30 miles per hour. The engine was designed by Mr. L. J. Monahan, and is manufactured by the Termaat & Monahan Company, of Oshkosh, Wis. They are operated by gasoline, kerosene, or crude oil, and a producer gas design is under consideration.

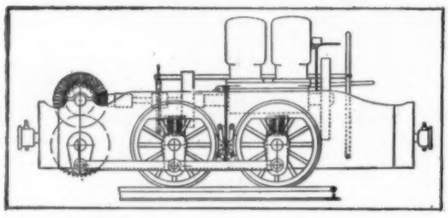
THE DUSTLESS SHOW WINDOW.

Just as the fogging of show windows in winter is regarded as a very troublesome matter, the settlement of dust on the goods in summer is a great source of evil, that often proves exceedingly costly to the proprietor of the store, because the goods are thereby often disfigured to the point of unsalability. Every show window must be ventilated in summer. For this purpose the lower ventilator slide in the show window base is opened, also the air door in the upper ventilating frieze, so that a draft is caused. It is easily understood that this leads to the introduction of a great deal of dust, which settles first on the glass panes in the show window, causing them to become dim, and making their frequent cleaning necessary if the show window display is to look presentable, which always requires the window to be cleared and consequently entails much labor and loss of time. The defilement with dust or even spoiling of goods in a show window is doubly unpleasant. Some shopkeepers could open quite a respectable account for "goods soiled or damaged in the show window."

It would be a simple matter to close the ventilation openings to prevent access of air and dust. This is, however, in the case of many windows impossible; first, because in rainy weather a great deal of moisture collects in the show window, which is expelled again by the strong current of air, so that the show window cannot become musty or stuffy; secondly, the upper air vents are often the sole ventilation for the store.



PLAN SHOWING ARRANGEMENT OF PARTS.

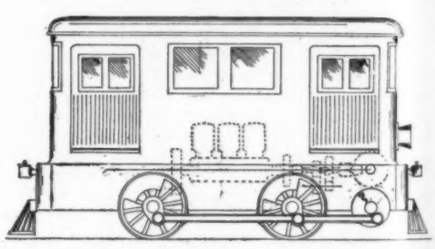


SIDE VIEW SHOWING ARRANGEMENT OF PARTS.

A very simple method of keeping the show window well aired and at the same time free from dust is the following, according to the Deutsche Uhrmacher Zeitung: Attach to the lower ventilators a light cloth or felt strips permeable to the air, or purchase a piece of fine wire gauze, between layers of which is a light fabric of sheepswool, that permits the free passage of air and is, at the same time, durable and consequently best adapted for this purpose. In Germany this is known as an "air filter." The strip must be so attached as to insure a tight closure. In the upper ventilation frieze, at the air valves, we apply the same fabric, so that the dust is arrested from below, as well as from above. Air will nevertheless find sufficient admission, so that the problem of keeping a well-ventilated show window free from dust is practically solved at once. This arrangement can be left in place in winter. It is the only certain means of protection against the troublesome fogging or frosting. It may be stated that the entire arrangement is almost invisible to the passerby.

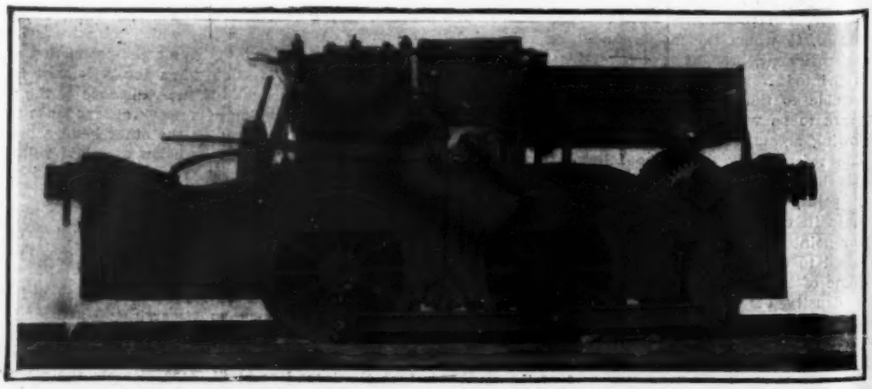
GASES IN STEEL.

Occluded gases in steel is the subject of a paper read by M. G. Belloc before the Académie des Sciences. The steel which he used in his researches was a nickel steel coming from the Imphy works, containing 45 per cent nickel and 0.15 per cent carbon, being in the form of wires or turnings, both coming from the same flow of metal. Following the same method which he used for ordinary steel, he finds that the occluded gases are carbon dioxide, carbon monoxide, hydrogen and nitrogen. The carbon dioxide is entirely driven off by heating below 520 deg. C., while the nitrogen escapes only at a higher heat. An interesting point of his experiments is the different behavior of the wire and the turnings. With the latter he obtained a total volume of gas equal to 3½ times the volume of the metal. The proportion of carbon monoxide increases up to 75 per cent, while the maximum value of the hydrogen lies at 540 deg. C., and then the amount is lessened progressively above this heat. In the case of the wire, the total volume of occluded gas is much larger, being ten times the volume of the metal. The variation in composition of the gases is no longer progressive. At 540 deg. C. there is a minimum of carbon monoxide and a maximum of hydrogen given off. These differences show that the wire and the turnings of the same metal behave differently in regard to occluded gases. The fact that the wire shows an irregularity as regards the gases leads him to believe that its molecular state is changed by the process of drawing. As to the difference in the volume of gas in the two cases, he attributes it to the difference in the distribution of gas in the ingot, such as has been found in ordinary steel, or else to the loss of the occluded gases by the action of the tool which produces the turnings, lastly, by absorption of gas in the wire during the processes needed for the drawing. These researches are of a nature to throw some light upon the general question of occluded gases.



AN ENGINE FOR INTERURBAN PASSENGER TRAFFIC.

A writer on the copper and brass industries states that scrap copper wire of high conductivity makes excellent metal, and if it is pressed together in small bundles the loss in melting is slight. Scrap telephone wire is not so good for brass-making because it often contains silicon.



A 8-TON ENGINE, DRAWING 100 TONS ON THE LEVEL AT 5 MILES AN HOUR, MEASURES 10 FEET OVER ALL.

A GAS LOCOMOTIVE.

REINFORCED CONCRETE POLES.

THE LATEST USE OF CONCRETE.

BY OUR ENGLISH CORRESPONDENT.

ONE of the latest developments in the use of reinforced concrete is in connection with the construction of poles and masts for the support of telephone and telegraph lines, transmission cables, trolley wires; in short, any variety of purpose for which wooden or iron structures are at present utilized. In this connection there should be a distinct future for this specialty, since wooden poles, although generally adopted, lack durability and are yearly becoming more expensive, owing to the ever-increasing demands on the available sources of supply. Similarly, iron or steel structures have the disadvantage of being somewhat costly in the first instance, while they require periodical renovation with paint to preserve them from rust.

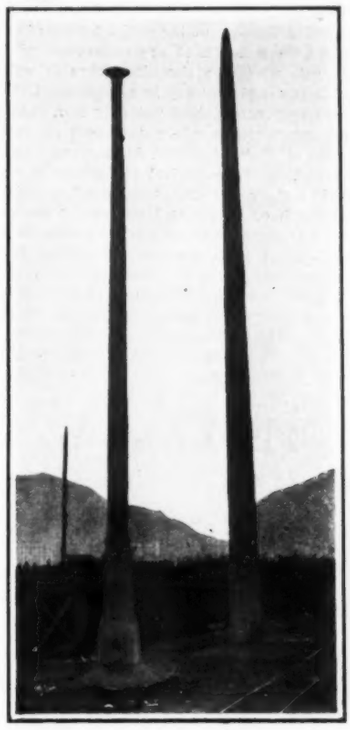
METHOD OF ATTACHING ARMS FOR SUPPORTING TELEGRAPH AND TELEPHONE WIRES.

Several efforts have been made to apply ferro-concrete to this field of industry. The majority of such poles have been of the solid type, in order to secure the maximum strength, but such a design is necessarily attended with great weight, rendering transport, especially over broken country, a matter of difficulty and expense. Attempts to minimize this disadvantage have been made by constructing the masts in sections convenient for handling, to be fitted together at the site of erection; but such a system not only increases the initial outlay, but at the same time impairs the strength of the completed structure.

However, this latter disadvantage has now been surmounted by a Swiss inventor, Herr H. Siegwart, who has succeeded in evolving a hollow ferro-concrete pole of great strength, which can be made economically on a special machine that he has designed. The design and principle of manufacture are both entirely new and ingenious, the maximum of strength being attained with the minimum of weight. Production is practically automatic throughout. The pole has a graceful taper, the degree of which can be increased or decreased to any requisite extent, and having a perfectly smooth outer surface has a neat appearance resembling, somewhat, a slender obelisk. The average thickness of the wall varies from one to two inches, according to the length and diameter of the pole and the load it is designed to carry.

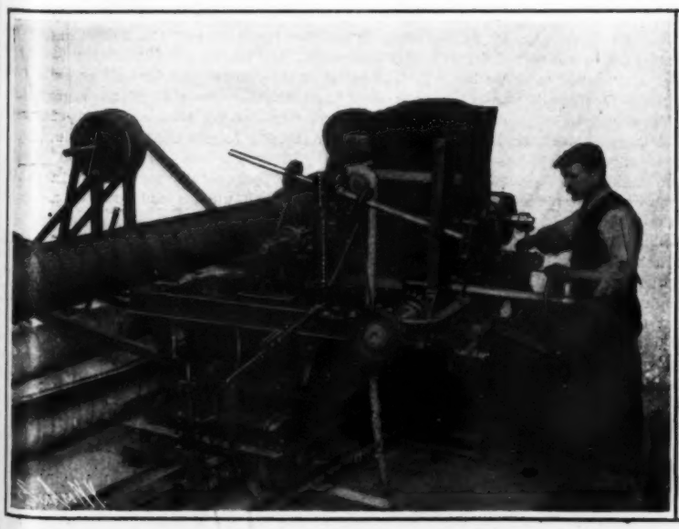
The principle of construction comprises the formation of a longitudinal annular disposition of steel rods, around which is spirally wound a continuous binding wire and a coat of concrete imbedding the longitudinal steel reinforcement. The hollow interior is formed by the insertion of a core of sheet iron during the process of manufacture, which is removed after the concrete has been applied, leaving a clean smooth internal surface. In order to facilitate the removal of this core, the circumference of the latter can be reduced. Along the entire length of this core, arranged at suitable distances from one another, gage rings are attached, upon which the longitudinal reinforcing rods are laid, being tightly stretched by means of screw-threads, thereby enabling them not only to be kept perfectly taut during the subsequent process of binding, but at the same time keeping them at an equal distance from the core and from each other. The core is mounted to revolve, but has no longitudinal movement. The machine for applying the spiral wire and concrete is mounted on a carriage running on rails laid parallel to the core.

This machine comprises two essential parts—the charging device or hopper containing the material, and the conveyer band carrying the concrete and depositing it upon the external surface of the longitudinal rods. The hopper has an opening at the bottom closed by a revolving drum, from the periphery of which project a number of short ribs or blades. The hopper is charged with the concrete, and when the drum is set in motion, each of the blades draws a certain quantity of concrete from the hopper and discharges it onto the conveyer band. By increasing or decreasing the rotating speed of this drum, the proportion of concrete can be regulated according to the thickness desired to be applied to the steel skeleton, there being an adjustable pawl with which the drum engages. The conveyer band is made of strong steel wire tightly plaited, which passes round the driving roller and is wound about the core. Care is exercised to keep this wire perfectly tight during the operation, it being stretched by a press roller under the influence of two heavily weighted levers, which apply a pressure up to 5,000 pounds per square inch. A chain-like device of links passes over this conveyer band, the sides of these links with the conveyer band as the bottom forming a continual series of shallow troughs or molds, into which the concrete from the hopper is deposited by the drum paddles. The links in passing around the core of the skeleton deposit their contents upon the exterior surface. The electric motor driving the various mechanism of the machine is mounted on the bottom frame of the machine, and transmits the power through a worm wheel and chains. The carriage itself is adjusted to the necessary angle, to enable it to follow the taper of the mast to be manufactured, and it also engages with a screw spindle extending throughout the whole length of the core, by means of which the machine is caused to travel along the outside of the core.



SPECIAL FORMS OF CONCRETE POLES.

The manufacturing operation is as follows: The concrete hopper having been filled and the motor



A MACHINE FOR MAKING HOLLOW REINFORCED CONCRETE POLES.

REINFORCED CONCRETE POLES PACKED ON A CAR FOR TRANSPORT.

HOLLOW REINFORCED CONCRETE POLES.

started, the conveyer band moves toward the core at the latter's largest end. Simultaneously the hopper drum commences to discharge the concrete onto the conveyer band, and is carried and deposited under the pressure of the press rollers upon the external surface of the steel rods in a continual spiral strip, lying very closely together, so as to form a complete continuous skin upon the core. While the latter revolves, owing to the movement of the conveyer band, a strong wire fed from a spool follows the deposit of concrete and is tightly wound round the core. This wire, which constitutes the transverse reinforcement, becomes imbedded in the concrete. Finally, press rollers come into play following the path of the wire-binding, kneading the concrete firmly upon the iron skeleton, so as to fill the interstices between the longitudinal rods, and also forming the inner coating to the latter by pressing the concrete against the sheet-iron core. In this way a uniform density of the fabric is assured, while at the same time the outer surface is smoothed down. When the concrete has thus been applied throughout the entire length of the skeleton, the pole is taken to the storeroom, where it is left to set, when the sheet-iron core is withdrawn. The pole is completely dry in a very short time.

It will be observed that not only is a pole quickly and easily manufactured by this process, but that a high-class concrete of perfect density and homogeneity is obtained. The mechanical production of such articles suitable for the transmission of electric power, for telegraph or telephone lines, or for the overhead mains of trolley street railroads, can be carried out cheaply and at a price below that of iron structures. If desired, any degree of ornamentation can be carried out, while by the admixture of coloring material with the cement the completed pole can be made to harmonize with its surroundings or resemble any material. The general method of carrying the cables and lines is shown in the accompanying illustrations. A cradle is attached to the upper end of the pole, the insulators being attached to the side vertical members.

Recently Herr Siegwart has applied the same process to the production of pipes for high-pressure water mains, the transportation of sewage, gas, etc., with conspicuous success. The same material as is adopted for ordinary cement pipes is used, the concrete being applied under heavy pressure, so that every inch of the pipe may receive the same pressure, whether the walls are 0.75 or 2 inches in thickness. Being manufactured by automatic machinery, production can be carried out upon a large scale and very economically, while any desired length can be easily secured. Already pipes capable of withstanding a hydraulic internal pressure of 285 pounds per square inch have been produced by this process and are in use.

The manufacturing process is practically the same as that followed in the case of the poles. The internal surface of the pipe is coated with a thin layer of asphalt, the thickness of which varies according to the water pressure under which the pipes are intended to work. The asphalt not only renders the fabric absolutely waterproof, but at the same time reduces skin friction by its smooth clean surface. For connecting the lengths together a special type of joint has been designed. One end of each pipe has a peculiarly shaped hollow, into which the adjacent end of the preceding member fits, and this depression is filled with asphalt, while a short length of piping or band is externally slipped over the joint and connected to the pipes within by a seal of asphalt. Even a pressure of 285 pounds per square inch has failed to start such a joint as this. The pipes are made in two grades—the first for high-pressure water mains, and the second for the transportation of sewage, etc., where pressure is not an important consideration. The former are made in standard lengths of 19 feet, and the latter in lengths of 12 feet. The great advantages of this system are the lower cost of the pipes; economy in working expenses, owing to the pipes being made in longer lengths, thus reducing the cost of laying; and durability, since the pipes are not subject to corrosive decay. Moreover, owing to the compact nature of the machine used for manufacturing the pipes, the latter in any important undertaking can be produced upon the spot. Recently some 22 miles of water mains in Roumania had been laid with the Siegwart ferro-concrete pipe in lieu of the cast-iron piping originally intended.

With regard to the ferro-concrete masts or poles, several severe tests have been carried out to determine their elasticity and capacity to carry heavy transmission lines as compared with the ordinary wooden or iron structures. For these investigations a pole measuring 39 feet 6 inches was selected. Its thicker end was anchored between two concrete blocks, while a strain was applied to its free end with a pulley, the strain exerted being measured by a dynamometer, and the deflection on a scale arranged at the top of the mast. With a load of 880 pounds the deflection was only 1.101 inches, which was increased to 3.463 inches under a load of 1,540 pounds, the permanent deflection owing to the strain being slowly released being 2.463 inch. In the second test the load of 1,540 pounds, which was applied, causing a deflection of 2.756 inches, was quickly released, when the top end of the pole instantly returned to its original position, so that no permanent deflection was perceptible. In the final test a load of 2,200 pounds was imposed, deflecting the pole 6.10 inches, with a permanent deflection of 4.725 inches. No signs of cracking, deformation, or fracture were however precipitated under this test, thereby testifying to the great strength of the fabric.

THE FOOT AS A LEVER.

TWO THEORIES EXPLAINED.

BY F. C. VAN DYCK.

The apparatus shown in the figure was devised by me for the purpose of adding interest to study of the foot, regarded as a lever.

The boards *ABC* have hinges at their outer ends marked *A*.

The triangular pieces, marked *B*, can be symmetrically placed anywhere between *A* and *C* on each side. The force required to lift the boards while empty, and the weight of the spring balance, may be noted and allowed for in computations of the results of experiments when great accuracy is desired.

While a person sustains himself the following relation exists in all symmetrical positions of *B* and *B* .....weight of man: balance reading = *BC* : *AB*. Also, since the force exerted by the man is transmitted as reaction to *B* and *B*, the ratio of the sum of pressure at those points to the balance-reading equals the ratio of *AC* to *AB*. The forces at all the axes, and the axis at which the agent's force is applied, being known, location of the fulcrum follows. The accepted principle may be thus stated:

The fulcrum of a lever is at the axis where that force acts which produces no displacement and therefore does no work.

VIEWS OF THE MAJORITY.

Almost unanimously it is assumed that a proper application of this principle locates the fulcrum at the toe, in case of the foot, at the blade of the oar, etc. This implies that the force at the central axis is to be regarded, in its entirety, as the resistance, or "weight." For instance, Watson's Physics (quoted because recent) says, "The pressure on the rowlock is the 'weight.'" .

Let this assumption be applied to the foot apparatus, taking numerical values for convenience. Place *B* and *B* so that *AB* = *BC* on each side, and let the weight of the man who lifts himself be 100 pounds. Then (disregarding weight of balance and boards, and computing for one side only) force at *C* = 50 pounds, and force at *B* = 100 pounds. If the point *B* is raised 1/10 of a foot from the plane of the hinges, the point *C* is raised 1/5 of a foot from that plane. The man's pull of 50 pounds is said to be exerted through 1/5 of a foot, doing work = 10 foot-pounds.

Obviously, the energy produced while raising the point *B* 1/10 of a foot should also amount to 10 foot-pounds. The kinetic energy produced is negligible, because the lifting is so done as to keep balance-reading constant. The energy produced of the form weight × height = 5 foot-pounds, and that of some other form should also = 5 foot-pounds. Is the latter 5 foot-pounds in an available form?

S.nce it is "begging the question" to assert that it is given back as the man lowers himself to his initial position some other test must be devised. Let the man, while in his highest position, cease to pull; the 50-pound reaction vanishes, but the 5 foot-pounds of

THE FOOT AS A LEVER.

form weight × height remains. The energy of form (?) exists, if at all, in some unfactored modification, since the "weight" has vanished. Perhaps it was "dissipated" during process of production. It would be interesting to discover that it pays to walk flat footed, avoiding use of the calf muscles.

VIEWS OF THE MINORITY.

They maintain that all the energy produced by the man lifting himself is of the form weight × height; none of the weight being figurative "weight."

They hold that whether a bystander lifts the man standing on the boards, or whether he lifts himself, in either case the space through which the lifting force is exerted is the increment of the distance between the hands and the feet of the agent. Applying this to rising on the toe, the distance through which the force of the calf-muscle is exerted is the decrease in length of the muscle.

They claim that in applying the above stated principle the usage in all cases, excepting the foot and its analogues, is to credit the displacement by which the energy is produced to *that force which remains the same for all values of the ratio of the sections of the lever*. For example, if a bystander lifts the man, the force at *B* is the same wherever *B* may be placed between *A* and *C*, and that force is said to produce the change in configuration of the system earth-body. If the man lifts himself, the force at *A* is the same for all values of the ratio *AB* : *BC*, and usage points to that force as affecting the change of configuration, and to *B* as the fulcrum. Hence distance moved by the point *C* is 1/10 of a foot, and the work done, by the force applied there, is 5 foot-pounds.

Take rowing as another instance. Here the energy produced is at first in the eddies, caused solely by the boat if oar-blades are applied above the water surface to posts driven into the earth underneath, and finally in the form of heat. In order that acceleration may be left out of account, let the speed of the boat be nearly uniform.

Then during any stroke the resistance of the water is analogous to the weight of the man who lifts himself on the boards, and the ratio of the sections of the oar may be changed *ad libitum*, if the angular sweep of the oar is correspondingly varied, without causing alteration of the speed of the boat or of the pressure of the oar blade on the water, or even of the frequency of stroke. Altering the ratio of the oar sections merely entails changes of the forces at hand and rowlock, just as the forces at *B* and *C* of the figure depend upon the ratio *AB* : *BC*. Accordingly the fulcrum is at the rowlock, and the pressure on it is only statically important.

The belief of the minority is that all cases of leverage may and should be treated alike, regarding all motion as relation dealing with each force in its entirety, and adhering to the same principle and the same usage.

Unanimity may be hopefully striven for in subjects which do not depend upon speculative data.—School Science and Mathematics.

A recording draft gage recently furnished to the Rand Water Board by the Cambridge Scientific Instrument Company for use with a battery of Babcock & Wilcox boilers is, in its elements, a balance in which the suction effect of the draft on a bell is opposed by the action of a helical spring. A lead pipe connected to the chimney is joined to the recorder by means of a union coupling, and communication is thus established between the chimney and the inside of a metal bell, whose mouth is sealed by dipping into the oil contained in an outer vessel. The stronger the suction the more the bell will be depressed. A helical spring pulls downward at the other end of the beam. A pointer with a pen at its end is attached to the beam, and records the draft on a revolving drum.

FUTURE OF THE ELECTRIC LOCOMOTIVE.

WHAT IT WILL DO FOR TRANSPORTATION

BY WILSON E. SYMONS.

THE birth of electric railways really occurred at Richmond, Va., in February, 1888, and in an article by Mr. Sprague published in the July issue of the Engineering Magazine, 1895, or about seven years after the completion of the Richmond road, and at a time when the honors showered on Mr. Sprague, and the extravagant prophecies for electricity and against the steam locomotive would have turned a less conservative man's head, Mr. Sprague among other things in an able article on "Will Trunk Lines Be Operated by Electricity?" very modestly and intelligently reviews the subject, saying among other things:

"That since the first line has been built, and put in operation, the United States, England, France, Germany and Italy have no less than 700 electric railways, covering 7,000 miles, and representing an investment of $250,000,000."

The very able analysis closed with a prophecy, which time has confirmed in every particular, and which I also quote:

"Let us lay aside then some of the visionary prophecies concerning electric railways with which probably no one has been more closely identified than myself: no one has greater faith in the electric railway than I, but its future is not in the wholesale destruction of existing great systems. It is in the development of a field of its own with recognized limitations, but of vast possibilities; it will cover such field to the practical exclusion of all other methods of transmitting energy; it will replace the steam locomotive on many suburban and branch lines; it will operate almost all street railway systems and elevated and underground roads; it will prove a valuable auxiliary to trunk systems, but it has not sounded the death knell for the steam locomotive any more than the dynamo has sounded that of the stationary engine; each has its own legitimate field, and will play its proper part in the needs of all civilization."

There are at the present time entering the city of Chicago some twenty-six trunk lines, operating with steam locomotives. These lines have an aggregate mileage of 90,285 or about 40 per cent of the total mileage in this country; 22,623 locomotives or 40 per cent of the total; 845,106 cars or about 42 per cent of the total, and with a valuation of $5,324,062,000 or a little over 31 per cent of valuation of all railways in the United States, which is placed at $16,-936,150,204. These companies operate in the city of Chicago, with few exceptions, steam locomotives using bituminous coal for fuel, and not infrequently contribute to the evils chargeable to the smoke nuisance, in a manner shown by photographs taken of an engine in service wherein it is assumed that 150 pounds of coal per square foot of grate area per hour is being consumed, with a loss of over 50 per cent of the fuel used.

There are in service in the city of Chicago approximately 650 locomotives, and assuming that each engine consumes 5 tons of coal per day, we have the combustion of 3,250 tons of coal per day; if 1 per cent of this total amount of smoke and soot permanently adheres to buildings, structures, etc., or contributes to the death or destruction of trees, grass, flowers, etc., or to the injury of clothing, people's health, etc., then the steam locomotive, it would seem, stands properly arraigned under a very serious indictment.

However, before rendering a verdict, let us take evidence from both sides, after which we can better determine the proper degree of responsibility.

There are hundreds, and I may say thousands, of chimneys in Chicago daily contributing to the evils of the smoke nuisance, and which no one familiar with the subject will dispute. The public mind, however, has of late been systematically and thoroughly poisoned against corporations, especially railway companies, and on this account the author is inclined to believe that a proper division of responsibility has not been made.

There are approximately 1,129,567 tons per year coming off from chimneys as smoke or soot, and about 1 per cent of this quantity of smoke or soot adheres permanently to buildings, structures, etc.

A comparison of the relative quantity of fuel used in the city by locomotives and that by stationary plants will show plainly the proportion each contributes. This should, however, be studied in connection with such conditions as surround each.

A division of responsibility serves to indicate on whom the burden of relief should rest with respect to abatement, and in this connection, it should be remembered that the schedule of miles, engines, cars and valuation of railways entering Chicago, also applies to many other cities and industrial centers; in other words, many of these lines have small interests here as compared to the sum total of their interests at other points, while the stationary plants are each one a unit in Chicago's sum total of assets, and in which we have seen that the steam locomotives only contribute 13 per cent of the smoke nuisance.

The author suggests consideration of an electric zone and submits a tentative plan by which all steam locomotives using bituminous coal will be, after a certain date, prohibited from entering the residence districts. Steam locomotives, regardless of the kind of fuel used, should be reduced to a minimum in numbers, on account of the noise their operation produces.

In the matter of stationary plants, which seem to be the arch criminals in this indictment, the author would invite attention to the view of a smokeless chimney, which is within range of every day operating conditions, except when first kindling fires, which is a very small fraction of the time. There are many plants, however, which continually produce smoke, and as a step toward effective and positive remedy, the police power in conjunction with proper engineering talent and practical experts, should regulate those plants, which are to be so designed and constructed as to be operated without emitting smoke; those outside of this qualification should be given ample time to either put in proper plants, or arrange to secure heat, light, electric current or power from some central plant, to be provided either by the city, or under its supervision, to the end that the smoke nuisance may be effectively and permanently abated without injury to any individual, corporation, or industry.

Wonderful progress has been made in the development of electric railways since Mr. Sprague's very conservative prophecy of twelve years ago. A report showing in a general way this development from 1888 to 1902 is as follows:

Companies	987
Mileage	22,576
Cost of road	$2,167,634,077
Number of employes	140,759,000
Number of cars	60,290,000
Number of passengers	4,774,211,904

In addition to this there has been a still greater development since 1902 than recorded prior to that time. Notable among these has been the interest shown by steam railway companies in the matter of electrifying certain sections of their lines.*

Notwithstanding the progress of electric transportation (as above outlined) we should not lose sight of the fact, that the steam locomotive has made greater strides in the matter of increased numbers, together with marked development or refinement both in the manufacture and the operation of the machine. Thus time tends only to confirm the truth of Mr. Sprague's prophecy as to the limits to which electricity and steam are respectively confined.

A very interesting and instructive paper was presented by Messrs. Stillwell and St. Clare Putnam at the meeting of the American Institute of Electric Engineers in New York city, January 25, 1907. Many valuable and interesting data was brought forth and analyzed in a way that could not but arouse much interest in this all-absorbing question. This summing up showed that in a general way the aggregate cost of operation of steam railways of America based on the expenses of 1905 would be reduced about $250,-000,000 by changing from steam to electricity. The proposition to electrify all of the steam railways of America is not, in the author's opinion, worthy of consideration, as it would be a practical impossibility from a financial standpoint; he would question the wisdom of undertaking changes of such magnitude when it is easy to determine that in order to realize the economies shown, it would be necessary to stand such unusual losses in other directions, and it would impose additional financial burdens of such magnitude that in the majority of cases bankruptcy would follow.

It would seem, however, a conservative proposition and one that would not impose unnecessary financial burdens on the people, or present any unusual complex engineering problems, to consider the introduction of electricity as a means of transportation in and adjacent to all large cities or commercial centers where the demand or the conditions are similar to those which have been and are being successfully met in New York city.

Chicago is suffering more from the smoke nuisance than New York ever did. It is also suffering from lack of adequate transportation facilities, and the substitution of electricity for the steam locomotive would provide relief in the matter of transportation; it would contribute relief with respect to the smoke nuisance in proportion to the degree of its responsibility. Both problems are easier of solution in Chicago than they were in New York, presenting no engineering or financial difficulties, which can not be reasonably and satisfactorily met, and it would seem there is really no excuse for further delay in securing necessary relief in this direction.

In order to illustrate more forcibly the probable future requirements in the matter of transportation let us review the increase in population for some years past, and at the same time observe what conservatively reliable estimates show for the future.

The increase in population in Chicago up to 1892 was about 11.2 per cent, since then, and up to 1901 less than 5 per cent. An average from 1837 to 1892 was 8.6 per cent, in 1902 estimated 2,000,000 population, and at 5 per cent compounded, it is fair to assume the future population will be about as follows:

1910	2,750,000
1920	3,250,000
1930	3,750,000
1940	4,500,000
1950	5,200,000

This is on the conservatively low average of 3 per cent, while if the national and local conditions governing the growth of Chicago were to average in the near future exactly as they have in the past, then the population would be at the following rate:

1910	3,500,000
1920	5,500,000
1930	7,750,000
1940	10,250,000
1950	13,000,000

It is hardly reasonable to assume that the latter figures will obtain; under the former figures, however, which are very conservative, it is not a great while until Chicago will be a city of 5,000,000 people, and as it is already over-crowded in the business districts with inadequate transportation facilities, which conditions are becoming more aggravated every day, and it is darker than London most of the time from smoke and soot, it is high time that Chicago should wake up not only to its present, but future conditions, and make provision for relief along these lines.

On the basis of our present population in the United States, and the transportation facilities to meet our requirements, it is not exaggerated prophecy, but a conservative estimate based on facts that in a few years we will be a nation of 150,000,000 people, and that the Mississippi Valley will be the home of 80,000,000 people.

Should transportation facilities be increased during the next twenty years in proportion to the lowest possible estimate, together with what is at present needed, the rail and water map may at that time reasonably be assumed to show 400,000 miles of main line and terminal facilities, and several thousand miles of canals and canalized rivers; the latter to include a deep waterway from the Lakes to the Gulf. The increased railway mileage would be approximately 170,-000 miles, and the increased number of locomotives necessary for its operation, based on present ratio of miles per engine, would be about 56,000; of this number at least 75 per cent, it is reasonable to assume, will be steam locomotives, which would bring the grand total up to or above the 75,000 mark with possibly 20,000 to 25,000 electric locomotives, or a grand total of 100,000 locomotives.

The cost of the above outlined improvements and additions may be conservatively estimated at $16,-000,000,000 or an amount equal to the present valuation of all railway property, created or acquired during the seventy-seven years of the period, 1830 to 1907.

Certain prominent railway men have been criticised for their outspoken views as to the country's future requirements in the matter of transportation. In the map shown all present railway lines are eliminated, the heavy lines indicate tentative location of approxi-

*Abstracted from paper read before the Western Society of Engineers.

*See Mr. Arnold's annual address, January 19, 1907.

mately 12,000 miles of broad-gage trunk lines 6½ to 7 feet gage, between the principal commercial centers; on these lines trains of special design and construction would handle 8,000 to 10,000 tons without interruption, and thus the prophecy of such men as Mr. E. H. Harriman and Mr. James J. Hill would not only be fully realized, but another distinct epoch in steam locomotive design would be added to its present interesting history.

A glance at the graphic chart not only shows past and present ratios of population, railway mileage, locomotives, cars, etc., but from this it can be seen that predictions as to our future requirements are conservative, and it should be specially noted that Chicago, the center and recognized mistress of the vast area tributary thereto, will if she keeps pace with the wheels of progress, profit more than any other point in the United States from such improvements as must necessarily be made.

Chicago, however, can never hope to be even reasonably clean or to enjoy sufficient interurban transportation service while she tolerates the smoke nuisance, from 650 steam locomotives and about 12,000 chimneys, of power plants burning bituminous coal.

The electrification of all steam railways, together with similar reforms in all stationary steam plants; or in event of complete success not being practical or feasible, then the city should install power, heating and lighting plants to supply heat, power, or light at a reasonable cost to those who either can not or will not install and operate a smokeless plant; this is to the end that Chicago's well deserved fame as the leading commercial and business city of the Mississippi Valley may be enhanced by taking rank as the most beautiful city.

The author is glad to acknowledge the kind assistance of Messrs. Bion J. Arnold, Frederick A. Delano, F. H. Burnham, Angus Sinclair, Slason Thompson, the Franklin Institute, and others.

THE MEASUREMENT OF OCEAN WAVES.

HOW STEREOSCOPIC PHOTOGRAPHY DETERMINES THEIR DIMENSIONS.

BY J. B. VAN BRUSSEL.

A KNOWLEDGE of the forms and motions of waves is of great practical value to shipbuilders as well as to navigators. Such knowledge is especially important in the construction of warships and passenger steamers in which it is essential to reduce rolling to a minimum for the comfort of passengers and crew and in order that the guns may be used in heavy weather.

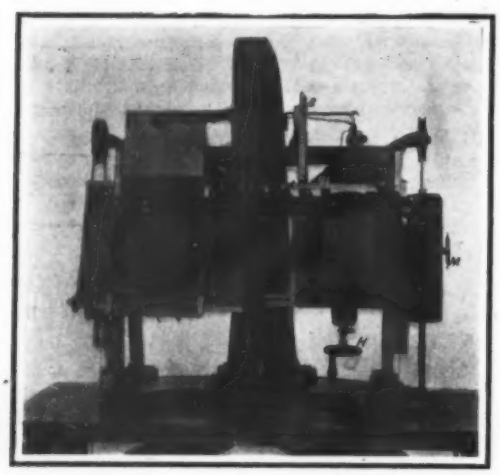


FIG. 1.—CAMERA MOUNTED ON THE BRIDGE.

In the opinion of experts, many recorded observations and measurements of ocean waves are utterly untrustworthy. The trochoidal theory of wave form, however, is found to agree fairly well with the results of numerous unexceptionable measurements, and to furnish a more or less useful basis for theoretical investigations of the motion of a ship through the waves.

Whether ocean waves are generated by the impact of irregular gusts or by the friction and suction of winds blowing steadily over the surface is not yet definitely decided, nor can any law connecting the size and shape of waves with the force of the wind be deduced from the few trustworthy observations that bear upon this point.

Approximate limits to the size of waves have been established. We know now that waves exceeding 40 feet in height are of very rare occurrence and there is no reliable record of a wave higher than 50 feet. The limit of length has not been fixed with such precision. Some observers claim to have measured wave lengths exceeding 2,600 feet, while others question the occurrence of waves longer than 1,600 feet. The same uncertainty attaches to the period of oscillation.

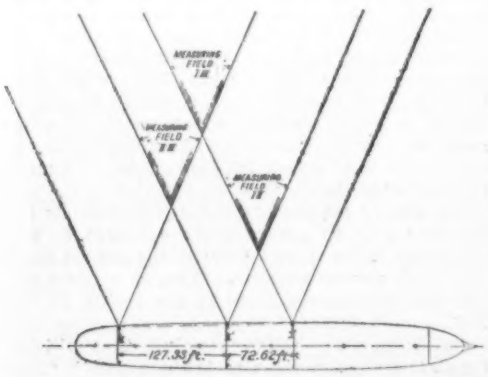


FIG. 2.—THE ARRANGEMENT OF THE THREE CAMERAS AND THE FIELD OF VIEW COMMON TO EACH PAIR.

Admiral Paris, of the French navy, gives the following mean values for the normal condition of the sea: Wave length 200 to 460 feet, wave velocity 36 to 50 feet per second, period 6 to 10 seconds.

With the methods of measurement that have hitherto been employed errors of 20, 30 and even 50 per cent are unavoidable.

Owing to the rapidity with which the wave changes its form and the uncertainty of observations made from a rolling ship, it is impossible to obtain accurate measurements except by the employment of instantaneous photography.

Stereophotogrammetry, a method based on comparative measurements of stereoscopic photographs, has lately come into use in land and topographical surveying and astronomy. These measurements can be most accurately made with an instrument, the stereocomparator (Fig. 1), which comprises a frame for holding the two stereoscopic plates and a stereoscopic microscope suspended in front of the plates on the overhanging steel arm *T*. Both plates can be moved horizontally, without relative displacement, by turning the wheel *H*.

The amount of this displacement is read from the scale *A*, which moves with the plates, by means of a fixed vernier. A common vertical motion is given to the plates by turning the wheel *V* and read from the moving scale *B* by a vernier. Thus the co-ordinates of any point of the picture are determined. The right-hand plate can also be moved toward or away from the other by the fine screw *M*. The relative displacement thus produced is read from the scale *A* by a vernier and lens and gives the stereoscopic parallax of the point under observation.

Prof. Laas, of Berlin, made a very interesting study of ocean waves by this method, on a recent voyage from Hamburg to Chile on the ship "Preussen." The course appeared favorable because it traversed high southern latitudes where large waves are developed in typical form by strong and constant west winds, but on this voyage no very high winds or waves more than 20 feet in height were encountered. Yet the experiment was very successful and many photographs were obtained from which not only the height and length of the waves but also the details of their form could be accurately determined. This result could not have been obtained by the usual methods.

In the stereophotographic method it is necessary to photograph the waves simultaneously from two points separated by an accurately known interval. Furthermore, the optical axes of the two cameras must be parallel and the plates must be in the same plane.

In order to provide against accident and insure accuracy Prof. Laas had three entirely similar cameras mounted on the front and rear of the bridge house and the front of the poop (Fig. 2) and made simultaneous exposures by electrical contact. Each plate could be combined with each of the others so that one triple exposure gave the equivalent of three independent pairs of stereoscopic plates, which to some extent covered the same field.

The cameras were very simply constructed of sheet brass and fitted with Goerz double anastigmat lenses of about 7 inches focus. The plates were 7 inches square.

The measurements with the stereocomparator were made after the voyage, for by this method the waves can be photographed at the most favorable instant and afterward measured at leisure, to any desired degree of detail.

Prof. Laas's results prove that the profile of an ocean wave is very different from a pure trochoid and that it normally represents the resultant of a number of component waves, irregularly combined. Hence most of the conclusions drawn from the assumption of a trochoidal form become worthless, and

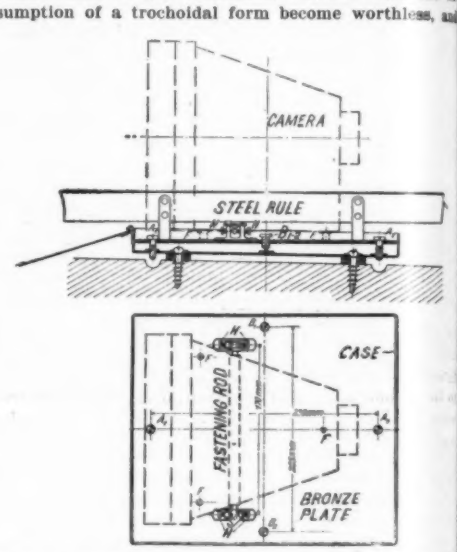


FIG. 4.—CAMERA AND BASE (PROFILE AND PLAN).

a new and more stable foundation for a theory of ocean waves must be built up by long-continued observation.

English and French shipbuilders have given much attention to wave motion for the past forty years. For the theoretical consideration of the effect of waves on stability, rolling, and resistance to progression all that is needed is a fairly close approximation to the lengths, heights, and the periods of waves. The period is the most important element and it is also the easiest to measure with certainty. The results of calculation can then be tested by experiments with models in tanks.

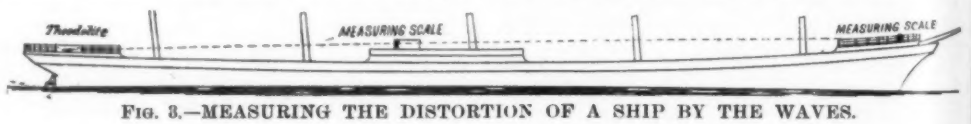


FIG. 3.—MEASURING THE DISTORTION OF A SHIP BY THE WAVES.

But the stresses and strains caused by wave action and, consequently, the requisite strength and stiffness of various parts of the ship, can be determined only at sea in rough weather. Only a beginning has yet

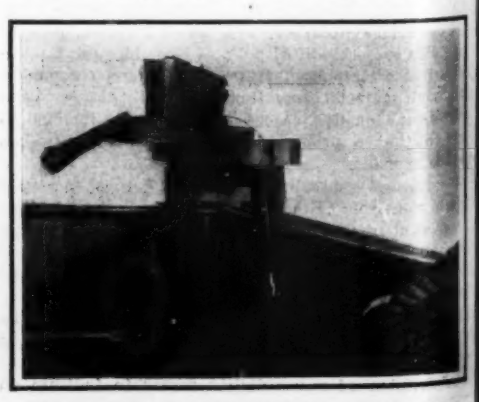


FIG. 5.—THE CAMERA MOUNTED ON THE FRONT OF THE BRIDGE.

been made in this field of research. On the outward voyage of the "Preussen," in ballast, Prof. Laas took occasion to measure the longitudinal deflection of the ship, in a vertical plane, by reading with a telescope on the poop vertical scales attached to the bridge and the forecastle (Fig. 3). In bad weather the displacements of the bridge, above and below the mean position, amounted to an inch and a half, and those of the forecastle to nearly 5 inches.

DETAILS OF METHOD AND APPARATUS.

The stereophotographic method of measuring the dimensions of waves involves two operations: taking the photographs and measuring them.

For effective use aboard ship the photographic apparatus must possess the following qualities:

1. Handiness. As the camera is used chiefly in bad weather, when the ship is rolling heavily, it must be small enough to be carried securely with one hand, leaving the other hand free to grasp a support.

2. It must not be easily injured by heat, cold, sea water, or careless handling.

3. It must be so constructed that it can be fastened quickly and securely at the desired point of view.

4. The plate must be exactly perpendicular to the optical axis.

5. The camera must have cross wires intersecting accurately in the axis.

The size of plate used was 7 x 7 inches. The height of the picture is much less than 7 inches but plates of this height are required for taking views to windward when the ship lies well over to leeward, as the lens was mounted rigidly for the sake of simplicity and security.

It was usually necessary to make the exposure as long as 1/100 second, so that the photographs are not very sharp, owing to the motions of the waves and the rolling of the ship.

At three points on each side of the ship bases were constructed on which the cameras could be so fastened that they always had the same positions with respect to the ship and each other (Fig. 4). Each base consisted of a bronze plate, 1/6 inch thick, mounted on four leveling screws, A, A_2, B, B_2, in a sheet brass case. The three feet, F, of the camera rested on this plate, to which the camera was secured by a rod attached to its bottom and passing through two sockets on the plate. As the six plates were adjusted to lie in one plane and the axes of the three cameras were parallel to and equidistant from the respective planes of their feet, the axes necessarily lay in one plane when the cameras were set on the bronze plates. The angles between the axes of the cameras could either be measured after setting up or adjusted to desired values by moving the sockets of the fastening rod by the screws H. It was finally decided, however, to set the axes parallel. The parallel position is the only one attainable without landmarks and it gives photographs which can be most easily measured with or without the stereocomparator, and also viewed in a stereoscope.

For each series of exposures the three cameras were mounted on the front and rear of the bridge and the front of the poop on one side of the ship (Figs. 2 and 3). The exact adjustment was made with the aid of three steel meter rules, mounted on legs of equal length. These rules were placed longitudinally and athwartship on the bronze plates (Fig. 4), which were then adjusted by their leveling screws so as to bring into coincidence the images of the rules as viewed with a theodolite in the poop. The cameras were then set up and the rules were attached horizontally to their backs and brought into line by moving the fastening rods by the screws H. The parallelism of the axes was tested by photographing the horizon to detect vertical deviations and objects of known or practically infinite distance to detect horizontal deviations. This could have been avoided, or nearly so, by the use of rigid and immovable foundations.

The real position of any object that is sharply defined in any two of the photographic plates may be obtained by the graphical method illustrated by Fig. 6. Here the distance between the plate line and the lens line represents, on any convenient scale, the common focal length of the cameras, while the distance between the axis lines represents, on a much smaller scale, the real distance between the axes of the cameras. On plate I the horizontal distance of the chosen object from the axis is measured and this distance is laid off on the plate line of the drawing, using the larger or focal length scale, from axis I, in the proper direction, to the point a. The same process applied to plate II establishes the point c. The point A, at the intersection of lines drawn from a and c through the respective lens points, is the representative in the drawing of the object selected in the two

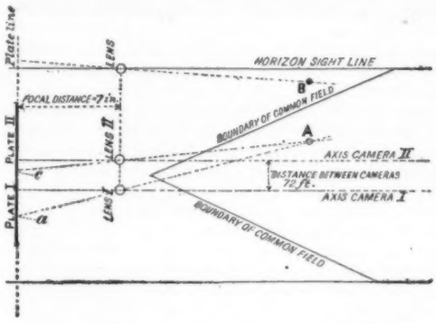


FIG. 6.—METHOD OF PLOTTING POINTS FROM THE PHOTOGRAPHS.

photographic plates, and the distances of A from the lens line and the axis lines represent, *on the smaller scale*, the real distances of the object in front, and to right or left of the real camera lenses. In this way a correct plan—not a perspective drawing—of salient objects in the common field of view can be built up, point by point, from the two photographs.

The height of the object or, in the case of a sea view, its distance below the horizon is obtained from one photograph as follows: On the same sheet (Fig. 6) is drawn a third horizontal line representing the line of sight of the horizon, and the plate line and lens line are prolonged to meet it. On the plate line the distance of the object below the horizon in the photograph is laid off above the horizon line (using the larger scale) and from the point so determined a line is drawn through the lens point. The intersection, B, of this line with a vertical line through A gives the position of the object in a vertical plane and the distance of B below the horizon line represents, on the smaller scale, the real distance of the object below the real horizon.*

In connection with the stereocomparator an essentially similar method of plotting is used, but not only can the photographs be measured far more accurately than with rule and compass but a great deal of fine detail can be included in addition to the conspicuous points to which direct measurement is restricted. By varying the method of plotting the surface of the sea can be represented by a topographical chart or by a series of profiles at definite distances.

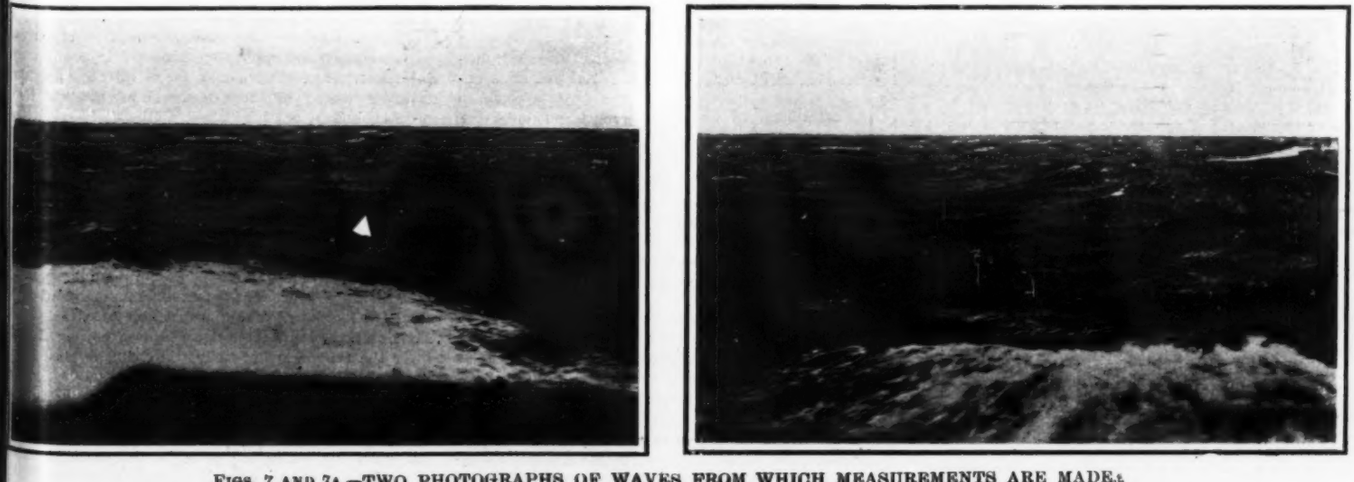
* Any confusion that may be caused by the use of the two scales will be removed by the statement that the small scale is employed, both horizontally and vertically, to the right, and the large scale to the left, of the lens line. It is evident that the scale of photographs, and the measurements made on them, can be increased to any desired extent without affecting the result, provided that the distance below the lens line and the plate line is increased proportionally.—Editor

Important additions to our knowledge of ocean waves can be acquired, as Prof. Laas remarks, only by numerous repetitions of these experiments and measurements.

THE KIEL CANAL.

ACCORDING to the most recent data as to the enlargement of the Kiel canal, this important enterprise will cost the German government no less than $55,000,000. The present undertaking was finished several years ago. The canal, which is also known as the "Kaiser Wilhelm" canal, has been carrying a considerable traffic since that time, but now it needs to be modified in order to meet the requirements of the modern craft. A preliminary credit of $4,000,000 was voted by the Reichstag in order to secure the rights of territory and to draw up the plans of the work. The locks for the vessels will be now 660 feet long and 150 feet wide, with 46 feet depth of water. Such a width may be considered as exaggerated, but it is thought that in the future the width of the vessels will be increased more than the other dimensions, and it is also desired to provide for a future enlargement of the canal. The width of the canal is now to be increased to 340 feet, with a 36 foot depth of water. The canal will keep its present path, except that it will be modified at two points where the present curves of 4,000 feet are too small and are dangerous for modern vessels of great length. This radius is now to be increased to 6,000 feet. The number of garages or side basins is to be greater than before and the distance between these will be lowered to 6 miles. This distance is considered to be enough for all the needs of the traffic, although it is more than in some of the large canals and especially the Suez canal, where it is only 3 miles. There will be two viaducts built over the canal, lying at 140 feet above water level and having 245 and 130 feet width respectively. The two revolving bridges for the railroad will be suppressed and will be replaced by viaducts so as not to hinder the traffic. The present project calls for the establishment of a new commercial port at the city of Kiel. The total expense of $55,000,000 includes 19 millions for excavation and dredging, 1 million for consolidating the banks, 16 for the two locks and 9 millions for reconstructing the bridges, etc. The cost of operating the canal will be considerably increased owing to the enlargement. The proposed work will require seven or eight years to carry out.

The Veeder Manufacturing Company has introduced a new speed indicator. This little instrument, unique in design, is capable of being run up to high speeds. It works equally well at high or low speed, and while it can be used for recording exceedingly high speeds, the limit of speed for which the instrument is recommended is about 5,000 R. P. M. The instrument has many excellent features, one being that an absolutely accurate count may be obtained without the aid of a stop watch. The counter is placed against the revolving shaft before it begins to count, and is held there for any length of time without disturbing the register. When the second hand of the watch reaches the beginning of a minute, a slight pressure on the end of the counter causes the clutch to engage, and the instrument instantly begins to count. It will continue to register until the pressure is relieved. The instrument works equally well in either direction. When run one way it adds, when run the other it subtracts. Where it is desirable to use the counter in connection with electrical machinery a rubber tip is provided, which effectually insulates the counter from any current there may be in the machinery. The counter is extremely compact and weighs but a few ounces.



FIGS. 7 AND 7A.—TWO PHOTOGRAPHS OF WAVES FROM WHICH MEASUREMENTS ARE MADE.

A PRIMER OF WOOD PRESERVATION.*

THE RETARDATION AND PREVENTION OF DECAY.

BY W. F. SHERFESEE.

THE cost of wood is to-day a big item to every farmer, every railroad manager, every mine owner—to everyone, in fact, who must use timber where it is likely to decay. How to reduce the expense of fence posts, railroad ties, mine timbers, telegraph poles, and other timbers which must constantly be replaced has become a vital problem. The kinds of timber used for these purposes are becoming scarcer and scarcer and their prices higher and higher. Long misuse of the forest has brought its sure result. Even with the most efficient management it would be a long time before the supply of the best timbers would increase in quantity or decrease in price.

There are two ways in which the situation may be met. One is to prolong the life of the forest by wise use; the other is to prolong the life of timbers in service by treating them with some preservative. It is the second of these methods of economy which is the subject of this circular.

It is easy to see that if the length of time timbers can be used is doubled, only half as much timber will be required as before and only one-half as much money will need to be spent in the purchase of timber. This is the chief gain in treating wood with preservatives. Yet there is another and important one. Many woods, which for a long time were considered almost worthless, can be treated and made to last as long as the scarcer and more expensive kinds. This of course means that the consumer will have the choice of a much greater number of woods than he had before and at less cost.

Wood preservation, then, prolongs the life of timbers in use, reduces their cost, and gives to the user a wider choice of woods than ever before.

Methods of preservation must be varied for different localities and different kinds of wood, and the Forest Service has issued several publications which deal with the problems presented in different regions. These publications and detailed information can be had upon application to the Forester.

WHAT DECAY IS.

The decay of a plant body, such as wood, is not an inorganic process like the rusting of iron or the crumbling of stone, but is due to the activities of low forms of plant life called bacteria and fungi. Bacteria are among the simplest of all forms of life, often consisting of but a single cell, microscopic in size. Sometimes several such cells may be attached to each other, and so form a thread or filament. Usually they are colorless, and multiply by the division of the parent cell into other cells, which, in turn, divide again.

Fungi, although much more complicated than bacteria, are also low in the scale of creation when compared with familiar flowering plants and shrubs. They consist merely of tiny threads or hyphæ, which are collectively known as the mycelium. In many of the higher forms of fungi the threads grow together to form compact masses of tissue. Familiar examples of these forms are the toadstools, which grow on damp, rotting logs, and the "punks," or "brackets," on the trunks of trees in the forest.

The causes of decay in wood, however, are not these fruiting bodies themselves. Spores, very primitive substitutes for seed, which are borne in the countless compartments into which the under surfaces of the fruiting bodies are sometimes divided, are produced in infinite number, and are so fine that they can be distinguished only by the microscope. When seen in bulk they appear as the finest dust. Like dust, they are carried by the wind and strike all portions of the surrounding objects. Few species of fungi successfully attack healthy living trees, and only a comparatively small number can attack and destroy wood. Yet the spores of some find a lodging in dead portions of a tree or in cut timber, and, if the wood is moist and in the right condition for the spore to grow, it germinates and sends out a thin, filmlike white thread, which, by repeated branching, penetrates the entire structure of the wood. These are the real agents of decay.

This is not the only way that a fungus can enter a sound stick of timber; for if a good stick is lying close to a rotting one, the mycelium may grow over or through the moist ground and so reach the sound stick, which it immediately attacks. Sometimes, too, when a tree is cut it already has a fungus growing in its wood. If the fungus happens to be a true parasite—that is, if it can grow only in living tissues—it will die when the tree is felled; but if it has been accustomed to growing in the heartwood of the tree, which is practically dead, it may continue to live and develop even after the tree has been sawed into timber.

* Circular 139 U. S. Forest Service.

Wood is composed of minute cells. The chief material of the cell-walls is a substance called cellulose, and around this there are incrusted many different organic substances known collectively as lignin. Most of the wood-destroying fungi attack only the lignin; others attack the cellulose alone, while a third class destroy all parts of the wood structure. The lignin and the cellulose are dissolved by certain substances secreted in the fungi, and thus serve as food for the fungus growth. In this way the fungi can develop until they extend throughout every portion of the timber. After a time the amount of fiber changed into food and assimilated by the fungus causes the wood to become discolored. Discoloration may also be produced by pigments in the fungus or secreted by it. Finally so much of the wood fiber is eaten away or changed in composition that its strength is greatly diminished, the texture becomes brittle and disconnected, and the wood is said to be "rotten."

But food is not the only thing that a fungus requires for its growth and development. It must also have heat, air, and moisture. If any one of these is lacking the fungus cannot develop. The necessary heat is supplied by almost every climate, and it is only in rare cases, as under water or deep under the surface of the ground, that air can be excluded from the timber. Of the four requirements, therefore, two are beyond control. It is only by depriving the fungi of food or moisture that the destruction they cause can be prevented.

HOW DECAY CAN BE RETARDED.

By Seasoning.—The simplest way of prolonging the life of timber exposed to the attack of wood-destroying fungi is to reduce the moisture content of the wood. The amount of water in green timber varies according to the part of the tree from which the wood is cut. The outer layers of the trunk are composed of sapwood, the cells of which contain large amounts of organic substances which serve excellently as food for the fungi. Moreover, sapwood always contains a large amount of water. It is the portion of the tree, therefore, most susceptible to attacks from fungi. Heartwood, which can usually be distinguished from sapwood by its darker or more reddish color, contains, on the other hand, much less moisture. It is therefore more durable than sapwood. But because its pores are stopped up by gums and resins it dries out much less rapidly than the more porous sapwood. In almost every case as much care should be taken thoroughly to dry out the heartwood as in the case of the moister sapwood.

By piling the timber so as to permit free access of air all around it the moisture content of timbers of certain sizes can be reduced to about 15 or 18 per cent. Of course the climate has a great influence on the rate at which the wood dries out and the total amount of moisture it loses.

The moisture content of air-dry wood can be still further reduced by kiln-drying; and this is employed to a considerable extent, but usually for other purposes than increasing the durability of the wood. Moreover, either air-dry or kiln-dry wood has the power to reabsorb moisture when exposed to the atmosphere in damp situations, and so the benefits of drying, as far as durability is concerned, are only moderate. Yet the increased life which it gives is, in nearly all cases, more than sufficient to repay the cost of the seasoning.

The strength of partially seasoned timber, other things being equal, increases as the amount of moisture it contains decreases. Thoroughly seasoned timber of small sizes is sometimes three or even four times as strong as the same timber, when green. Moreover, during the process of drying out, important but little understood changes take place in the organic contents of the wood cells, by which the wood is not only rendered less attractive to fungi, but is made more permeable and so better prepared for preservative treatment. All timber should be thoroughly seasoned before being exposed to decay.

An exterior coating secured by dipping a post in a thin solution of cement or other material that will harden on the post is not an effective protection, because in shrinking or swelling the wood forms cracks through which decay enters.

By Chemical Impregnation.—By far the best method of checking the growth of fungi, however, is to deprive them of food. This can be done by injecting poisonous substances into the timber, and so changing the organic matter from foods suitable for fungi into powerful fungicides. It is a mistake to suppose that the germs of decay are inherent in the wood, and only need an opportunity for development to bring about its destruction. Several processes for the preservation of wood have been founded on the false assumption that it is necessary to destroy the "germs" in the interior of the timber. The impression doubtless arose from the fact that, after a stick of timber begins to rot, it is impossible to tell just where the fungus spores germinated and gained entrance into the timber. Moreover, the fact that the interior of the wood may have reached an advanced stage of decay before there are any external evidences of the fungi—such as fruiting bodies, or films of mycelium—tends to convince the casual observer that decay starts from the interior. Yet the wood-destroying agencies start from the outside. This explains the efficacy of certain paints which merely form a superficial coating over the surface of the timber, but which are poisonous enough to prevent the spores from germinating, or the hyphæ of most forms of wood-destroying fungi from penetrating into the unprotected wood in the interior. The ancients were in the habit of painting their statues with oily and bituminous preparations to preserve them from decay. The great wooden statue of Diana at Ephesus, which was supposed to have descended miraculously from heaven, was protected from earthly decay by oil of nard. Pettigrew extracted the preservative fluids from the heart of an Egyptian mummy that had resisted decay for over 3,000 years, and found that decomposition immediately set in. This showed that it was the presence of the antiseptics which prevented decay, and not a chemical change of the tissues.

PRESERVATIVES AND PROCESSES IN THE UNITED STATES.

Of the many antiseptics which have been proposed for the preservation of timber only four have been largely used with success in the United States. These are creosote, zinc chlorid, corrosive sublimate (bichlorid of mercury), and copper sulphate. At the present time copper sulphate has fallen into almost total disuse, and corrosive sublimate is restricted to two plants in New England. The use of this latter is the so-called "kyanizing" process which is so frequently referred to in all the literature of wood preservation. In general, the process consists in steeping the timber in a dilute solution of corrosive sublimate long enough to insure thorough penetration.

Creosote and Zinc Chlorid.—Thus in the United States creosote and zinc chlorid are the only preservatives in common use. There are many other patented substances known by various names; but most of them have for their base one or the other of these two preservatives. Creosote is a by-product of coal tar, which is produced at most plants for the manufacture of illuminating gas and at by-product coke-oven plants. This tar is distilled and during the process the condensed vapors are run into three separate vessels and thus separated into the light oils of coal tar or naphthas, the dead oil of coal tar or creosote, and pitch. Creosote is not a simple substance like zinc chlorid. On the contrary, it contains a large number of constituents of great chemical complexity.

Wood tar, when distilled in a similar manner, gives "wood creosote," which like that derived from coal tar, possesses strong antiseptic properties. There is also on the market a so-called creosote, a by-product of water-gas tar or tar manufactured from kerosene oils, which for wood preservation is probably inferior to the true creosote. In general, however, by "creosote" is meant the dead oil of coal tar.

Zinc chlorid is obtained by dissolving metallic zinc in hydrochloric acid. This is further diluted by water before it is used for wood preservation.

Just as there are two preservatives in common use, so there are two principal methods of injecting them into the timber. These may be called the "pressure-cylinder method" and the "open-tank method." A third process, known as the "brush method," is used to a more limited extent.

The Pressure Processes.—Up to very recent times the pressure-cylinder method was used almost exclusively in the United States. With creosote it is known as the Bethell process, and with zinc chlorid the name of Burnettizing is applied. The timber to be treated is placed on iron trucks or "cylinder buggies" and drawn by steel cables into huge horizontal cylinders, some of which are 8 or even 9 feet in diameter and more than 150 feet long. These are capable of withstanding high pressure, and their doors are so arranged that, after the timber is drawn in, they can be closed and hermetically sealed. It is common practice in this country—a practice which long experience in Europe, as well as in America, has proved to be unwise—to treat the timber before it has had time to dry out in the open air. The following is the usual method: After the doors are closed live steam is admitted into

the cylinder, and a pressure of about 20 pounds per square inch is maintained for several hours, the exact time depending upon the individual opinion of the operator, as well as upon the moisture content and size of the timber under treatment. In some cases the steam pressure is allowed to go considerably above 20 pounds, but there is constant risk of injuring the strength of the timber. When the steam is at last blown out of the cylinder, the vacuum pumps are started and as much of the air as possible is exhausted from the cylinder and from the wood structure. This process also continues for several hours. Finally, after the completion of the vacuum period, the preservative is run into the cylinder and the pressure pumps are started and continued until the desired amount of preservative fluid is forced into the wood. The surplus preservative is then blown back into the storage tanks, the timber is allowed to drip for a few minutes, and finally the cylinder doors are opened and the treated timber is withdrawn.

The Open-tank Process.—The injection of the preservative by the open-tank process depends upon a different principle.* The wood is first thoroughly seasoned, and much of the moisture in the cells and intercellular space is replaced by air. If the timber is peeled soon after cutting, and stacked in open piles, the time required for seasoning can be greatly lessened. The seasoned timber, or that portion of it which is to be preserved, is immersed in a hot bath of the preservative contained in an open iron tank. This hot bath is continued for from one to five or six hours, depending upon the timber. During this portion of the treatment the air and moisture in the wood expand and a portion of them pass out, appearing as little bubbles on the surface of the fluid. At the end of the hot bath, as quick a change as possible is made from the hot to a cold preservative. This causes a contraction of the air and moisture remaining in the wood, and, since a portion of it had been expelled, a partial vacuum is created which can be destroyed only by the entrance of the preservative. Thus atmospheric pressure accomplishes that for which artificial pressure is needed in most of the commercial plants. Whether the open-tank or pressure-cylinder method is the more desirable depends upon the particular conditions of each case. Both methods have their particular uses and neither can always be wholly substituted for the other.

The Brush Method.—A less efficient but cheaper treatment can be secured by painting the surface of the timber with at least two coats of hot creosote or some similar preservative.† The liquid may be applied with an ordinary paint brush, but care should be taken to fill thoroughly with the preservative all checks, knot holes, and similar defects. The liquid can penetrate only a very short distance into the wood, but as long as there remains an unbroken antiseptic zone around the surface, the spores of the wood-destroying fungi cannot enter. It is especially important in this method that the timber should be thoroughly air-dry before treatment. Otherwise the evaporation of water from the interior of the stick will cause checks to open up and so expose the unprotected wood to fungous attack.

This process finds its principal use where the amount of timber to be treated is too small to justify the erection of even a small treating plant; where the land is so rugged, as in the building of mountain telephone lines, that it is impracticable to transport the timber for even short distances, or where it is necessary to restrict the cost of the treatment to the lowest possible figure.

The Effect of Treatment on the Strength of Timber.—The question is frequently asked whether or not the strength of timber is impaired by the processes in common use for wood preservation. No general answer to this can be given, since it depends altogether upon the character and strength of the preservative and the care with which it is injected. It is probable that creosote does not penetrate the wood fibers, but merely forms an external coating around them; hence, in itself, it cannot appreciably affect the strength of the timber. In general the ultimate strength of treated timber depends, first, upon the percentage of moisture remaining in the wood; and, second, upon whether or not the wood has been subjected to injuriously high temperatures during the preliminary processes of steaming and vacuum, if these processes were employed. The degree of temperature which can be applied without risk of serious injury depends upon the duration of the temperature, the moisture content and quality of the wood, and upon the pressure to which it is subjected.‡

If proper care is observed in the treatment of the timber all danger of injury from excessive temperatures can be avoided. The amount of moisture remaining in the wood is therefore a point of greater importance. As the moisture in a piece of wood is reduced by drying, the strength of the wood increases, and as moisture is subsequently reabsorbed, the strength up to a certain limit is again reduced. Creosote retards both the absorption and evaporation of water; hence its presence in thoroughly seasoned wood exposed to humid conditions tends to conserve its strength, whereas, on the other hand, if it is applied to green wood the strengthening action of water-evaporation is retarded. Some processes tend to increase the moisture content of the wood and others to diminish it. Therefore, whether the strength of timber is increased or decreased during creosoting depends chiefly upon the process employed.*

The effect which live steam at safe temperatures has upon the moisture content of wood is now being made the subject of a special study. It is safe to say, however, that during steaming the amount of moisture in air-dry timber is increased, with a consequent decrease in strength, and that the succeeding vacuum fails to remove all of the added moisture before the introduction of the preservative. With many kinds of air-dry timber, however, the steaming can be dispensed with altogether, and this is done in many commercial plants. Whether or not it can be omitted with all kinds of wood is not yet certain.

These considerations, of course, do not apply to the open-tank method, or to similar processes where the timber is immersed directly in the hot preservative, without the preliminary steaming and vacuum. Immersion in hot oil tends to evaporate some of the moisture in the wood and so to increase its strength.

Zinc chlorid and the other preservatives which are in water solution have a wholly different effect. Unless the wood structure is already filled with moisture to the point of saturation, more water is injected into it with the preservative, with the result, if the wood is partially seasoned, of decreasing its strength. The original strength may be regained, however, by seasoning. If the zinc chlorid is injected into the timber in too concentrated a solution it may cause a chemical dissolution of portions of the wood fiber, with the result of permanently decreasing the strength of the timber. But for the solutions in common use this danger need not be taken into consideration.

Both creosote and zinc chlorid are excellent antiseptics, and both can be obtained in large quantities. Creosote's principal point of superiority, however, lies in its insolubility in water. Hence, once it is injected into timber it will not wash out, no matter how wet may be the situation in which the treated timber is placed. On the other hand, zinc chlorid is much cheaper than creosote, and since it is shipped in the form of a solid the freight charges are considerably less than they would be for enough creosote to treat the same amount of timber. But zinc chlorid is soluble in water, being in fact injected into the timber in water solution, and so when timber treated with zinc chlorid is exposed to moisture the leaching out of the salt is only a question of time. Hence, zinc chlorid is most commonly used in comparatively dry situations. Creosote, on the other hand, is used where the timber will be subjected to moisture. Moreover, creosote is one of the very few preservatives within commercial reach which offer absolute protection against the marine borers, which work such havoc among the wharves of the Atlantic, Gulf, and Pacific coasts. Since it is insoluble in water it can not wash out of the piles into which it has been properly injected, and since it is more than a mere external coating there is no danger of its being broken off by floating débris.†

TENDENCY OF WOOD PRESERVATION IN THE UNITED STATES.

In the United States the tendency in wood preservation is to modify the processes rather than to change the preservatives. At present, creosote and zinc chlorid, pure or in mixture, are the only preservatives which are in general use. A constant effort is being made to overcome the chief drawbacks to the use of each of these. Processes have been developed which involve the compression and expansion of the air in the wood structure to expel some of the expensive creosote, leaving only a film along the cell walls. The amount of oil left in the timber is reduced, and in consequence the cost of the treatment as well. In other cases zinc chlorid and creosote are mixed together and injected into the timber in the form of an emulsion, the object being to reduce the cost of the treatment and to prevent the zinc chlorid from leaching out of the timber. Sometimes the timber is impregnated with zinc chlorid, and only a narrow outer layer is filled with creosote; or again, glue and tannin are employed in the effort to plug up the outer wood cells and so keep the salt in the interior.

THE SAVING IN DOLLARS AND CENTS.

No process to preserve timber can come into use unless it is certain that the outlay for the treatment will be more than offset by the longer service of the treated timber. It is difficult to give a general example of the saving effected by treating certain timbers with preservatives, since it depends so largely upon local conditions and the class of timber. The following examples of the saving which under certain circumstances can be effected by proper preservative treatment are, however, typical, although they may not apply to other localities and to other kinds of timber without some modification:

An untreated loblolly pine fence post cost about 8 cents, or, including the cost of setting, 14 cents. Its length of life in this condition is about two years. Compounding interest at 5 per cent, the annual charge on such a post is 7.53 cents—that is, it cost 7.53 cents a year to keep such a post in service. If given a preservative treatment, which costs about 10 cents, the length of life of the post is increased to about eighteen years. The total cost of such a post, set, is then 24 cents, which, compounded at the above interest rate, gives an annual charge of 2.04 cents. Thus the saving due to treatment is 5.49 cents a year. Assuming that there are 200 posts per mile, there is a saving each year for every mile of fence of a sum equivalent to the interest on $219.60.

The saving due to treating railroad ties is also worthy of consideration. A loblolly pine tie untreated is worth about 30 cents, and its length of life in this condition is about five years. To this first cost should be added the cost of laying, which is about 20 cents. The annual charge figured as above is then 11.52 cents. If treated it will last for about twelve years. Its cost of treatment is about 35 cents. A treated tie in the track, therefore, costs about 85 cents. Compounded at 5 per cent, as in the above example, its annual charge is 9.48 cents. The saving per year is therefore 2.04 cents per tie. Assuming 2,880 ties per mile of track, the saving due to treatment alone amounts to $58.75 per mile, which corresponds to an investment of $1,175 per mile.

Assuming that the cost of an untreated oldfield or loblolly pine pole, including hauling and setting, is $5, and that it lasts five years—a fair estimate for many portions of the United States—the annual charge, compounding interest at 5 per cent, amounts to $1.15. In other words, it costs the owner $1.15 a year for every such pole in his lines. This corresponds to a capital of $23 invested at 5 per cent interest, or, for a mile of 40 poles, to $920. Again, assuming that the butt of such a pole can be treated for $1, the first cost of the pole, set in the ground, is $6. The treatment may reasonably be expected to secure a service from the pole of twenty years, instead of five years when untreated. Thus, the annual charge on the treated pole, with the same rate of compound interest, is only $0.48 per pole, which corresponds to an investment of $9.60; or $384 per mile, as compared with the $920 per mile in the other case. Thus during the life of the treated pole a yearly saving of the interest on $536 will be effected for every mile of line.

It might be said that it is not positively proved that the treated poles will last twenty years, and that it will be necessary to wait until the poles are finally removed before the length of their service can be determined. A sufficient answer to this argument is that treated poles need to last only 1.6 years longer than untreated poles in order to justify the cost of treatment. Moreover, there is abundant evidence to show the long life of creosoted wood.* Even in this country there are many examples of poles and other timbers creosoted twenty and even thirty years ago, which today are apparently as sound as when first set in the ground. In Europe, where wood preservation is an older industry, the results are still more marked. There have been failures, but in every instance they can be traced to incompetent or fraudulent work, insufficient impregnation, improper preparation of the timber, or some similar cause.

WHAT WOOD PRESERVATION CAN DO IN THE FUTURE.

At the present rate of consumption the exhaustion of the supply of structural timbers in the United States is a thing of the very near future. Moreover, the cost of fence posts is an ever-increasing burden upon the farmer and stockman. In the case of structural timbers telephone poles will serve as an example. Statistics gathered by the Forest Service show that in 1906 more than 3,500,000 telephone and telegraph poles were cut. This includes only poles 20 feet and over in length, and ignores the far greater number of poles and posts of smaller sizes. Of the poles cut, at least 40 per cent, or nearly 1,500,000, were either of white cedar or of arborvitæ.

Under average forest conditions it requires more than one hundred and ninety years to grow a 30-foot cedar pole. The average life of such a pole, when set in the ground in its natural state, does not exceed fifteen years. In other words, in order to meet even the present annual consumption there must be nearly thirteen trees growing in the forest for every 30-foot cedar pole standing to-day. A study of the rates of growth and the durability of other kinds of wood used for other purposes—ties, mine props, piling, etc.—shows

*See Forest Service Circular 101, "The Open-Tank Method for the Treatment of Timber."

†See Forest Service Circular 104, "Brush and Tank Pole Treatments." Detailed discussions of these points will be found in Forest Service Bulletins Nos. 39 and 108.

*A discussion of the moisture content of creosoted wood may be found in Forest Service Circular 134, "The Estimation of Moisture in Creosoted Wood."

†A more detailed discussion of this may be found in Forest Service Circular 128, "Preservation of Piling Against Marine Wood Borers."

*See Forest Service Circular 98, "Quantity and Character of Creosote in Well Preserved Timbers."

that the consumption of structural timber greatly exceeds its production. Yet relief can be had in prolonging the length of service of the timber now being placed in position. Most of the cross-ties placed in the track to-day must be renewed within eight years. But if their life can be lengthened to fifteen years the benefits of the preservative treatments are plain. It is estimated that 150,000 acres are required each year to grow timber for the anthracite coal mines alone. The average life of an untreated mine prop is not more than three years. By proper preservative treatment it can be prolonged by many times this figure. Poles which in ten or twelve years, or even less, decay so badly at the ground line that they have to be removed can, by a simple treatment of their butts, be made to last twenty or twenty-five years. The same is true of fence posts and other timbers exposed to direct contact with the soil. Sap shingles, which are almost valueless in their natural state, can be easily treated and made to outlast even painted shingles of the most decay-resistant woods. Thousands of dollars are lost every year by the so-called "bluing" of freshly sawed sap-wood lumber. This can often be prevented by proper treatment and at a cost so small as to put the method within the reach of the smallest operator. Millions of feet of insect and fire-killed timber in the West are standing untouched in the forest. Under present conditions this timber is not only useless, but is an actual detriment to the forest. Much of this dead wood possesses all the requirements of high-grade structural timber, with the single exception of durability. Often where dead timber is most abundant there is an almost complete absence of the naturally durable kinds of wood, and timber for structural purposes—ties, mine timbers, poles, posts, etc.—must be transported long distances at heavy expense. The thorough seasoning of several years has strengthened the dead wood and put it in an excellent condition for treatment. Fortunately, most of it is of a kind which readily absorbs the liquid preservatives, and so is well adapted to successful impregnation. Therefore, expensive pressure plants are, in most cases, unnecessary, and the cost of erecting and operating a small open-tank treating plant is surprisingly low. In the South the cheap and abundant loblolly pine, one of the easiest of all woods to treat, can by proper preparation be made to take the place of the high-grade longleaf pine for many purposes. Black and tupelo gums and other little-used woods have a new and increasing importance because of the possibility of preserving them from decay at small cost. In the Northeastern and Lake States are tamarack, hemlock, beech, birch, and maple, and the red and black oaks, all of which by proper treatment may help to replace the fast-diminishing white oak and cedar. In the States of the Mississippi Valley the pressing fence-post problem may be greatly relieved by treating such species as cottonwood, willow, and elm.

HYDROGENIT.

A new process for manufacturing hydrogen gas for aeronautic purposes is based on the decomposition of water at ordinary temperature by a specially prepared aluminium compound, made of aluminium filings, to which are added a small quantity of bichloride of mercury and cyanide of potash, both pulverized. This compound forms a coarse metallic powder, giving out a small amount of heat. Its apparent density is 1.42, and it keeps indefinitely in an air-tight vessel. Its most remarkable property is its action upon water. One kilo (2.2 pounds) of this compound, treated with an excess of water, produces about 1,300 liters (39 cubic feet) of hydrogen gas at a temperature of 15 deg. C. (59 deg. F.). About 800 grammes (28 ounces) are sufficient to produce 1 cubic meter (35.37 cubic feet) of gas. On account of this peculiarity it is called hydrogenit.

To produce the gas, the compound is placed in a receiving vessel, and a small amount of water is added to it. After a few seconds the reaction begins, making itself apparent by a progressive rise in temperature. This production of heat regulates the rapidity of the decomposition of the water, which is the more thorough the higher the temperature of the reacting products, although it should not surpass 80 deg. C. (176 deg. F.). By keeping the temperature at about 70 deg. C. (158 deg. F.) by the introduction of a variable quantity of water, the amount of the aluminium in the compound will become thoroughly oxidized in two hours.—Génie Civil.

An interesting discovery is stated to have been made by a wharf builder of San Francisco who was rebuilding an old wharf in which the piles had been badly destroyed by borers—*Teredo navalis*. One pile was found to be thoroughly sound, and a careful investigation of the cause of this exception revealed the fact that the pile had been used to support a live wire. He then carried out experiments with electricity upon wooden piles, and discovered that the teredo would not bore into a pile in which a very small current was maintained.

ELECTRICAL NOTES.

A system has recently been invented by an American named Mr. C. Fish, of supplying the necessary red and yellow rays in the mercury vapor lamp. The rays from the latter are projected on to a glass reflector in such a way that the reflected rays mingle with light passed directly through the light-transmitting reflector from a source placed on the opposite side. The red and yellow rays are usually supplied by ordinary incandescent electric lamps.

The Electrical World states that the company which is working the 40,000-kilowatt hydro-electric plant at Nottoden, Norway, for the fixation of atmospheric nitrogen by the Birkeland and Eyde process will shortly make an addition of no less than 200,000 horse-power to its manufacturing capacity. The present plant produces nitrites for the textile industry, and the new plant will manufacture nitrite for agricultural purposes and also nitric acid. The present plant, which consists of four 10,000-kilowatt generators, has been very successful in its technical operation, while the product has been disposed of at a profitable price almost invariably in advance of production.

On the Teltow canal in Germany, where the boats are propelled by electricity, an ingenious rogue has conceived the idea of making use of the electric current for obtaining a supply of fish. All that was necessary was to attach one end of a piece of wire to the electric feed wire and dip the other end in the water. All the fish within a radius of 30 feet were instantly paralyzed and could be caught easily with a scalp net. The trick is not a new one. It had already been employed on the Aire canal by French poachers but it is doubtful if they originated it. It is probable that the inventor of the device has never made a claim of priority.

In an article on the discharge of electricity through gases in the May number of the Journal de Physique, M. P. Villard, after a critical examination of the present view that the luminous phenomena are due to ionization or recombination, comes to the conclusion that the opposite is the case, ionization producing darkness rather than light. His own experiments lead him to the further result that the positive column is not an assemblage of independent particles, but an object of the nature of a vortex filament behaving like a flexible and extensible conductor, only capable of existing in gas ionized to an extent lying between certain limits, but within these limits becoming more prominent and stable as the current is increased. The arc and electric spark, according to M. Villard, are intense discharges in which the positive column plays the most important rôle, the negative phenomena having disappeared, while in the vacuum tube discharge the opposite holds.

To reduce refractory material such as alumina, magnesia, and silica in the electric furnace, says the Electrician, the following conditions are necessary: (1) The temperature should be brought nearly to the point of decomposition by the employment of the oxide and finely divided carbon in definite proportions. (2) The reduced metal should be immediately carried from the high temperature to a low temperature zone, these being in the case of aluminium about 3,000 deg. C. and 800 deg. C. respectively. A furnace, recently patented in the United States, by E. Viel, consists essentially of carbon plates. Its bottom is built on a sharp inclination and at its lowest part water circulation is fitted. The material is placed in a hopper, at the upper part of the furnace, which is connected to the lower half by a helix through which the material passes. Two electromagnets fitted on the carbon carriers operate the arc, which plays on the material inside the furnace. By the use of suitable methods the arc may be directed to any one part of the furnace so that the material is quickly brought to a high temperature and descends rapidly toward the cool zone.

In countries which possess an abundant source of cheap power in the form of waterfalls, employment of electricity in cooking is recommended by its simplicity, convenience, and cleanliness. The following examples of its use are cited by L'Industrie Electrique: Partly in consequence of the difficulty of obtaining fuel, but mainly for reasons of convenience, electric kitchens have been installed in two Alpine hotels, one at Moserboden, in the Tyrol, the other at the Mer de Glace of the Jungfrau, in Switzerland, at an altitude of nearly 10,000 feet. At Moserboden 93.4 kilowatts, at 120 volts, are employed for the service of two kitchens and the hot water supply of the hotel. One kitchen contains a 16-gallon boiler for meat and soup, and a 12-gallon boiler for potatoes; the other kitchen is equipped with two roasting and baking ovens and a coffee roaster. The hot water service, which includes the laundry, requires four boilers with an aggregate capacity of 550 gallons. The installation at the Jungfrau hotel is of similar character. Here the current, at a tension of 125 volts, is furnished by a transformer connected with the trolley wires of the Jungfrau railway.

TRADE NOTES AND FORMULÆ.

Moldable and Plastic Asbestos Mass.—The asbestos is reduced to a powder, from which, by an admixture of water, a uniform mixture is produced; then, while stirring, more water is added, so that a paste is formed, which is allowed to stiffen by drying, until the mixture attains the required plasticity. Out of this mass, objects may be formed, especially filter material for the filtration of wine, vinegar, acids, and other fluids, which, after being dried for a time, can be burned out in a furnace.

Quick-Hardening and Slow-Hardening Cements.—A quick-hardening cement, for wood, glass, porcelain and metal, that resists water fairly, can be made from a mixture of finely powdered litharge and glycerine. A slowly hardening cement, on the other hand, is made by mixing cement and 25 per cent of brick dust, with sour milk to a thick paste. For stone and garden statuary, this cement is excellent; it is, however, preferable to first coat the objects to be cemented with a dilute solution of water glass.—Seifensieder Zeitung.

To Give Copper Goods a Fine Red Finish.—Fine copper goods are first hammered until matt, then painted inside with salt water, but outside with a lye made from 1 part vine twig ashes, 2 parts ammonia and 9 to 12 parts of water. The coated articles are heated over a charcoal fire and slowly immersed in clean water. Then treat them with ordinary pulverized rouge, rubbing them with a leather to which white wax has been applied and hammer them. Objects that are not to be tinned may be treated with a mixture of 3 parts of fresh milk and 1 of water, mixed with rouge, applied lightly and allowed to dry thoroughly.

Argentine for silvering copper and brass is made as follows, according to Töllner: 30 parts of nitrate of silver are dissolved in 100 parts of distilled water. Then add, while stirring, a solution of 10 parts of chloride of sodium in 100 parts of distilled water, as well as a triturated compound of 65 parts of washed chalk, 30 parts of tartaric acid, 150 parts ammonia fluid (0.960), and 60 parts distilled water. The mixture must be kept in a dark place. In using the mixture, the copper, brass, or copper-plated iron articles to be silvered must be thoroughly cleansed with spirit of salammoniac and well rubbed with the argentine, which must be vigorously shaken up, applied with a soft woolen cloth, until it shows a bright silver coating. Then it must be washed off with weak water. Under the same name, another silvering mixture is known, consisting of a solution of cyanide of silver in concentrated cyanide of potash solution mixed with some washed chalk. (Very poisonous; use with care.)

To Transfer Copper Plate Prints or Lithographs to Wood.—Only hard, fine-grained woods, chestnut, lime tree, maple, and white birch can be used and must be prepared by rubbing down with ordinary linseed oil, carefully dried and warmed over a charcoal fire and drying again. The copper plate print must be a clear print and clean, and must be softened by soaking in salt water. In the meantime the wood surface must be uniformly, but thinly, coated with varnish (50 parts sandarac, 25 parts of fine shellac, 12 parts of Venice turpentine and 300 parts of alcohol). When the last coat of varnish is dry, remove the print from the salt water and lay it on blotting paper. In the meantime prepare a good straight board, well smoothed, not warped and somewhat larger than the print, which must be heated over hot coals; give the wood surface its last (fourth) coat of varnish, also apply a coat to the picture side of the print, and at once place it with its varnished side on the varnished wood, lay a piece of thick flannel with the heated board on it and compress it with hand screws. The varnish must not have dried before the pressing. After two or three hours remove the hand screws. Remove the paper carefully with water, rubbing with a sponge and the finger. Finally apply a thin coat of linseed oil to the paper and rub it on. When finished, dry dustless and coat with polishing varnish.

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